THE EFFECT OF ENERGY STRATEGY ON AUSTRALIAN ECONOMIC SECURITY

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ROBERT R. GALVIN, MAJOR, U.S. ARMY RESERVE
B.A., Florida Atlantic University, Boca Raton, Florida, 1993

Fort Leavenworth, Kansas
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It is unlikely that any nation could use energy products as leverage against the Australian government. As a key US security partner worldwide (particularly in the Pacific basin), the integrity of the Australian economy is a significant concern to both governments. Australia is a major player in the world energy market as both a petroleum consumer and a supplier of coal, natural gas and uranium. Potentially, a hostile government could exploit Australia's energy economy to influence national policy. This paper examines the current Australian internal and external energy economies for potential points of vulnerability as well as likely developments within 25 years. Australia's redundant energy sources make it less vulnerable to embargo than many developed economies, while the expanding world energy market provides alternative customers if an Australian energy customer refused to purchase the country's coal, natural gas or uranium.

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Name of Candidate: Major Robert R. Galvin

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Approved by:

_____, Thesis Committee Chair
Phillip G. Pattee, Ph.D.

_____, Member
LTC Jerry Moon, M.A., M.S.

_____, Member
Harold A. Laurence, M.S., MBA

Accepted this 12th day of December 2014 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, Ph.D.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE EFFECT OF ENERGY STRATEGY ON AUSTRALIAN ECONOMIC SECURITY, by Major Robert R. Galvin, 102 pages.

It is unlikely that any nation could use energy products as leverage against the Australian government. As a key US security partner worldwide (particularly in the Pacific basin), the integrity of the Australian economy is a significant concern to both governments. Australia is a major player in the world energy market as both a petroleum consumer and a supplier of coal, natural gas and uranium. Potentially, a hostile government could exploit Australia's energy economy to influence national policy. This paper examines the current Australian internal and external energy economies for potential points of vulnerability as well as likely developments within 25 years. Australia's redundant energy sources make it less vulnerable to embargo than many developed economies, while the expanding world energy market provides alternative customers if an Australian energy customer refused to purchase the country's coal, natural gas or uranium.

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ACRONYMS

CNG	Compressed Natural Gas
CSG	Coal Seam Gas
DAP	Direct Action Plan
EIA	US Energy Information Agency
ERF	Emissions Reduction Fund
MSR	Molten Salt Reactor
NEM	National Energy Market
OPEC	Organization of Petroleum Exporting Countries
PRC	People’s Republic of China

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CHAPTER 1

INTRODUCTION

In a November 17, 2011 speech before the Australian Parliament, President Barack Obama emphasized the importance of the Pacific basin to the American economy:

> Here, we see the future. As the world's fastest-growing region—and home to more than half the global economy—the Asia Pacific is critical to achieving my highest priority, and that's creating jobs and opportunity for the American people. With most of the world's nuclear power and some half of humanity, Asia will largely define whether the century . . . As President, I have, therefore, made a deliberate and strategic decision—as a Pacific nation, the United States will play a larger and long-term role in shaping this region and its future, by upholding core principles and in close partnership with our allies and friends.[1]

Australia and the United States are close allies, and face many of the same challenges, including a dependence on imported petroleum for both transportation and petrochemical feed stocks. This dependence on imported petroleum is a strategic vulnerability, as these supplies are prone to interdiction or constriction. Since Australia relies on petroleum to fuel its military, an interruption in imports could directly affect Australian security.

As a key US security partner worldwide in the Pacific, the integrity of the Australian economy is of significant concern to policy makers in both countries. This study will examine Australian energy strategies to determine if a hostile power could leverage Australia's economic dependence on energy commerce to manipulate the country's government policies.

This question leads to several corollaries. First, what domestic energy sources can Australia reasonably expect to develop in the next 30 years? Since projected Australian petroleum reserves should provide sufficient fuel to meet the requirements of the

Australian security forces for the next 30 years, the use of alternative energy sources (especially for transportation) could in theory reduce Australian petroleum consumption to the point that domestic production could meet military requirements.

The second corollary is related to the first: is nuclear power a politically and economically viable option for Australia? Australia has considerable reserves of uranium; if used for power generation, Australia could eliminate the coal-fired power plants that currently provide much of the nation's power. This would decrease carbon dioxide emissions, and if used to power electric vehicles, reduce the need to import petroleum for transportation.

Finally, is Australia's dependence on coal and natural gas exports for foreign exchange a strategic vulnerability? If so, could a hostile foreign power exploit this to influence Australian foreign policy? Australia is a major supplier of coal and natural gas on the world market; these exports supply the country with considerable foreign exchange. A foreign power that could prevent or control these exports could control the Australian economy.

Scope, Limitations and Delimitations

The focus of this study is to determine what options Australia has for energy production in the near to medium future (within the next 30 years). There are several important limitations affecting the scope of this study. First, this paper will not address any classified material. Second, the timeframe of the study is 30 years; this is the longest that an informed analyst can predict energy production requirements and production, due to potential changes in technology, consumption and energy supplies. Third, the date of the interviews of Australian officials (October 31, 2011 through November 4, 2011) will

limit the information and opinions they can provide on the latest revisions to Australian policy, especially the Carbon Tax Act. Finally, the Information Cut Off Date for this study is August 3, 2014.

Assumptions

This study depends on two assumptions. The first is that fossil fuel hydrocarbons will remain an international commodity for both power consumption and chemical production for the next 30 years. Second, the study assumes that no unforeseeable breakthroughs in energy technology will fundamentally alter energy production and distribution for the next 30 years.

Significance of Thesis

Since the Second World War, the security strategies of Australia and the United States have been closely intertwined. The Australian military currently secures many unstable regions in the Pacific basin, and contributes considerable personnel, expertise and political support to US interests around the world, especially during the Global War on Terrorism. Australia will need reliable energy supplies to honor these security commitments in the future.

Background

Australia is an island continent with a modern, Western society and a capitalistic economy. The Australian energy economy is highly complex; political, economic and social factors combine in ways that complicate energy production even more than technical considerations. Australia has per capita energy consumption similar to the United States, and the Australian government predicts that energy requirements will

increase two percent annually between 2005 and 2050.[2] While Australia is a net exporter of fossil fuel, declining domestic production and rising consumption force the country to import liquid petroleum, primarily for transportation.[3] The country was the world's second largest exporter of coal in 2011,[4] and among the world's largest exporters of uranium[5] and natural gas.[6] Australia has extensive reserves of coal, natural gas, and uranium. Similar to the United States, energy production and consumption have prompted Australia to pursue a variety of means to meet its energy needs. These include the most effective utilization of domestic fossil fuel resources, conservation, and alternative energy sources.

In order to evaluate various energy strategy options, one must understand the significance and national security implications of energy policy. Since the rise of the coal economy in the United Kingdom in the early eighteenth century, inexpensive and readily available energy has fueled progress in the Western world. Generally, fossil fuels provided much of this energy. Initially, domestic sources in the English-speaking world were sufficient to meet demand, but the twin pressures of depletion and increasing demand prompted the United States and Australia to seek additional reserves and limit consumption through conservation.

Australia has extensive proven reserves of both brown and black coal. According to the US Energy Information Administration (EIA):

> Australia exported about 70 percent of its coal production (about 314 MMst) in 2011. The country was the world's largest coal exporter for over two decades, and fell behind Indonesia on a weight-basis this year. According to the Australian Coal Association, Japan was the destination for nearly 40 percent of Australia's black coal exports in 2010. China, Australia's second largest market for export coal, held a 14-percent share and doubled its export levels from the year earlier. Other top markets included South Korea (14 percent), India (11 percent), and

Taiwan (9 percent). Most exports are from the Queensland and NSW states, although Western Australia began exporting coal in 2007.[7]

In addition to exporting coal for profit, coal fuels about 75 percent of Australian electricity production.

The EIA estimates that Australia has 1.5 billion barrels of proven petroleum reserves. Production peaked at 828,000 barrels a day in 2000, and has gradually decreased since. Consumption is currently over one million barrels a day (primarily for transportation), making the country a net petroleum importer.

According to the EIA, Australia produces over 1.5 trillion cubic feet of natural gas annually, of which one trillion cubic feet is consumed domestically, making the country a net exporter of natural gas. The EIA estimates that Australia has approximately 30 trillion cubic feet of reserves, sufficient to meet projected domestic needs for the next 30 years; however, poor production methodologies can reduce the total volume of gas a field can produce.

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[1] Matt Compton, "President Obama Addresses the Australian Parliament," The White House Blog, November 11, 2011, accessed December 8, 2011, http://www.whitehouse.gov/blog/2011/11/17/president-obama-addresses-australian-parliament.

[2] Australian Department of Resources, Energy and Tourism, *Uranium Mining, Processing and Nuclear Energy- Opportunities for Australia?* (Canberra: RET, Commonwealth of Australia, 2010), 15.

[3] US Energy Information Administration (EIA), *Country Analysis Brief: Australia* (Washington, DC: EIA, 2013), 5.

[4] Ibid.

[5] Australian Department of Resources, Energy and Tourism, *Australian Resource Assessment* (Canberra: RET, Commonwealth of Australia, 2010), 15.

[6] EIA, *Country Analysis Brief: Australia*, 10.

[7] Ibid., 15.

CHAPTER 2

LITERATURE REVIEW

The governments of both Australia and the United States recognize the importance of reliable energy supplies to economic growth and security. Both perform copious research in the energy field, including domestic and imported fuel sources, as well as energy production and consumption. In the United States, the EIA has primary responsibility for monitoring energy production and consumption worldwide to provide the US government and private companies with data and analysis to inform decision making. Several Australian government agencies monitor the energy economy from securing energy products (by either extraction of domestic supplies or importation) to production and consumption.

The Australian Department of Resources, Energy and Tourism monitors fossil fuel extraction as well as energy production, distribution and consumption, and produces reports periodically to inform government officials and private citizens of current developments. The *Australian Energy Resource Assessment*, published in 2010, is a comprehensive review of Australian energy production and potential. Covering fossil fuel, nuclear and renewable energy, the *Energy Resource Assessment* examines both the Australian domestic energy market and overseas sales of fossil fuel and nuclear products. Generally neutral in regards to energy production, this study examines both current industry practices and possible future energy sources.

In November 2012, the administration of Prime Minister Julia Gillard formally published the *Energy White Paper* as an outline for government policy over the next four years. In contrast to the Australian *Energy White Paper* advocates stronger government

leadership in energy policy, and opines that the carbon tax on energy production (enacted in late 2011) will have a positive effect on domestic development of clean, renewable energy. At the same time, the study commits the Australian government to policies that ensure affordable energy for the entire nation.[1]

Nuclear Power in Australia

In 2006, the government of Prime Minister John Howard commissioned a detailed survey of uranium mining in Australia and the viability of nuclear power in the future.[2] *Uranium Mining, Processing and Nuclear Energy* (the resulting study) examined Australia's current nuclear situation, including uranium mines in operation and the regulatory environment at the federal and state levels. The study was generally favorable towards nuclear power development, based on Australia's decades of experience in operating nuclear research reactors and the country's proven uranium reserves. The government finished the study in 2006, with a generally positive view of nuclear power's future role in Australia; however, the 2007 election of the current Labor government placed any changes to Australian nuclear policy on hold. The 2010 election of Julia Gillard as Prime Minister, and her need to create a coalition with the Green Party, effectively ended the discussion of nuclear power in Australia during her term in office.[3] The administration of current Prime Minister Tony Abbott may choose to reopen this debate in the future.

Greenhouse Solutions with Sustainable Energy

In contrast to *Uranium Mining, Processing and Nuclear Energy*, Mark Diesendorf argues in *Greenhouse Solutions with Sustainable Energy* that when measured against

objective criteria, nuclear power is not more economical across the entire lifecycle of the plant than renewable energy sources.[4] According to Diesendorf, the economic realities of nuclear power forced the United Kingdom to subsidize nuclear plants with a surcharge on consumers. The author also raises valid concerns about the danger nuclear waste and nuclear accidents pose to the public.

As indicated by the title, *Greenhouse Solutions with Sustainable Energy* presents options for clean power generation, including wind, solar, and tidal systems. The author advocates government intervention vice market forces to change the type and pattern of energy use in the country, suggesting, for example, that the national and state governments increase the cost of using public roads to force the use of more fuel-efficient vehicles and transportation nodes. Diesendorf also advocates government intervention to create more disbursed urban communities consisting of numerous neighborhood hubs containing government and commercial activities surrounded by residences within walking distance.

While Diesendorf presents many compelling arguments based on government and academic studies, he also makes some sweeping generalizations without supporting evidence. For example, the author opines that the use of private (vice public) transportation is a direct causative factor in obesity;[5] however, there is no obvious correlation between public and private vehicle ownership and body mass, which is affected by a number of genetic and life-style factors.[6]

In addition to sweeping generalizations, Diesendorf advocates the use of technologies with little proven track record of success; including the deep-water sequestration of greenhouse gases. Diesendorf readily admits that scientific evidence for

the efficacy of deep-water sequestration but ignores the fact that natural releases of greenhouse gas are well documented, sometimes with tragic consequences. On the night of August 21, 1986, carbon dioxide dissolved into Lake Nyos in Cameroon spontaneously released. The resulting gas cloud asphyxiated over 1,700 people and considerable numbers of livestock, which compounded the disaster.[7]

Energy White Paper 2012

Like most developed nations, Australia has a formal energy strategy. In November 2012 the Department of Resources, Energy and Tourism published the government's first comprehensive energy report since 2004,[8] the *Energy White Paper*. This comprehensive document explains the Labor Party's stance on the Australian internal, import and export energy economies as well as likely future developments and reflects the Gillard administration's focus on pollution reduction and energy efficiency. The *Energy White Paper* examines all aspects of the domestic energy market and the effects that international agreements (such as the Kyoto Protocols) will have on this market. The paper examines some issues through 2050 but restricts its scope of recommendations to the next four years.[9]

The *Energy White Paper* embraces a comprehensive system of education, regulation and private sector engagement to ensure clean, sustainable energy for Australian public, private and business users; the needs of indigenous communities are explicitly included.[10] The paper recognizes that many Australians in remote areas have no access to grid power and declares the government's commitment to providing affordable energy to them.[11]

The *Energy White Paper* is comprehensive in many aspects but leaves important issues unanswered. A significant shortcoming is the assumption that Australia can rely on energy technologies that have yet to be proven (or in some cases, to be invented) to meet future energy needs without harming the environment. A prime example of this is the matter of energy storage. By suggesting that renewable energy sources can supplement fossil fuel (especially coal) for energy production, the *Energy White Paper* strongly implies that some form of efficient, affordable energy storage medium will allow clean energy to supply baseline capacity on a continental scale. Unfortunately, no such technology currently exists, nor does the *Energy White Paper* explain how Australia will develop such a capacity.

Another weakness is the paper's reliance on carbon capture technologies to allow Australia to use fossil fuels to generate power while meeting Kyoto Protocol goals.[12] Like energy storage technologies, carbon capture (which typically involves injecting carbon dioxide into deep wells at high pressure) is a promising technology that has yet to demonstrate economic viability on a continental scale. While the study acknowledges the need to study possible dangers of pumping high pressure fluid into coal seams to release coal seam gas,[13] it does not mention any potential dangers of injecting high pressure greenhouse gases into the earth.

While the Gillard administration is generally liberal in orientation (and thus not amenable to domestic nuclear power), the report tends to be neutral on the idea, briefly citing the technical issues of domestic nuclear power[14] while concentrating on the export market for nuclear fuels.[15] The *Energy White Paper* acknowledges that some European countries are phasing out nuclear power (Germany in particular) and that the March 2011

tsunami in Japan and resulting nuclear emergency may affect nuclear exports but predicts that new markets in South Korea and the People's Republic of China will offset these losses.

The *Energy White Paper* confirms that fuel exports are a cornerstone of the Australian economy,[16] and forecasts that this trend will not only continue but increase, with natural gas production to quadruple by 2017.[17] The study predicts that the world coal market will decrease by 27 percent in the near to mid-future[18] but still expects that mining will directly employ about 53,000 Australians by 2017.[19] What the paper does not address is how international agreements like the Kyoto Protocols will directly or indirectly affect energy exports. While natural gas burns much cleaner than coal or petroleum fuels, it still generates greenhouse gases to produce usable energy and thus contributes to the users' carbon burden. Should changes in foreign markets or domestic pressure from Australian environmentalists force the country to limit fossil fuel exports, significant damage to the Australian economy could result. Taken as a whole, the *Energy White Paper* is an important survey of the current state of the Australian energy economy and policy statement of Gillard administration, but has a significant gap between the administration's goals and the technologies necessary to realize those goals.

Current Prime Minister Tony Abbott ran for office on a number of issues; criticism of the Labor Party's energy strategy was a central campaign issue.[20] Upon assuming office, the Abbott government immediately began to dismantle the framework of laws on which the *Energy White Paper* depended. This renders the Gillard administration's energy strategy and the 2012 *Energy White Paper* null and void. The

Abbott government soon began to formally outline a new energy strategy in late 2013, and expects to release a new *Energy White Paper* in September 2014.

Head of State

Numerous domestic and overseas issues beset Australia today, including on-going military operations in Afghanistan and the Solomon Islands, and growing public debt. In spite of this, energy is the most divisive subject in Australia today.[21] *Head of State: the Governor-General, The Monarchy, the Republic and the Dismissal*, by David Smith, provided significant insight into the structure and operation of the Australian government at the federal level.

Similar to the United States, the government of Australia consists of three elements: the executive, legislative and judicial branches. The judicial branch functions similar to the Supreme Court of the United States; the legislative and executive branches are entirely different. The executive branch is led by the Governor-General, who functions as the local representative of the Queen of the United Kingdom.[22] The Queen appoints the Governor General on the advice of the Prime Minister. The constitutional duties of the Governor-General are ambiguous, but are in no way comparable to the chief executive of the United States.

The Australian Parliament consists of two houses: the lower House of Representatives and the upper Senate. To form an effective government, a party must hold a majority quorum in the House of Representatives. A party can form such a quorum in one of two ways: either by winning the majority of seats during an election or, in the event no single party holds a majority, by forming a coalition government. For the first time since 1949, the 2010 elections resulted in a hung parliament. The Labor party holds

72 seats, while an opposition coalition (led by the conservative Liberal party) holds 72 seats. A small number of Green party and cross-bench ministers support the Labor party, allowing it to form a coalition government with a majority of two.

In the event of a hung parliament, the constitutional requirement to form a coalition government gives minority party members disproportional power; if a single non-Labor member of the coalition leaves, the Labor party will no longer be able to form a quorum and the current government will fall. The Green party has assiduously taken advantage of this situation to advance legislation that would otherwise not pass through the House of Representatives.[23]

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[1] Australian Department of Resources, Energy and Tourism, *Energy White Paper 2012* (Canberra: RET, Commonwealth of Australia, 2012), 5.

[2] Australian Department of Resources, Energy and Tourism, *Uranium Mining, Processing and Nuclear Energy- Opportunities for Australia?*, 15.

[3] Senator Eric Abetz, interview by author, Canberra, Australian Capital Territory, November 3, 2011.

[4] Mark Diesendorf, *Greenhouse Solutions with Sustainable Energy* (Sydney: University of New South Wales Press, 2007), 247-268.

[5] Ibid., 186.

[6] T. J. Parson, C. Power, S. Logan, and C. D. Summerbell, "Childhood Predictors of Adult Obesity: A Systematic Review," *International Journal of Obesity and Related Metabolic Disorders* 23, Supplement 8 (1999): abstract, S1-107.

[7] Robert H. Socolow, "Can We Bury Global Warming?" *Scientific American* (July 2005): 54.

[8] Australian Department of Resources, Energy and Tourism, *Energy White Paper 2012*, 4.

[9] Ibid.

[10] Ibid., 212.

[11] Ibid., 211.

[12] Ibid., 67, 99.

[13] Ibid., 76.

[14] Ibid., 98.

[15] Ibid., 68.

[16] Ibid., x.

[17] Ibid., xi.

[18] Ibid., 27.

[19] Ibid., 206.

[20] Mike Anderson and Ann Koh, "World's Highest Carbon Tax Bedevils Australia's New Leader," Bloomberg, June 28, 2013, accessed June 29, 2013, http/;//www.bloomberg.com/news/2013-06-28/world's highest carbon tax bedevils australia's new leader.html.

[21] MP Oliver Woldring, interview by author, Canberra, Australian Capital Territory, October 31, 2011.

[22] David Smith, *Head of State: The Governor-General, the Monarchy, the Republic and the Dismissal* (Sydney, New South Wales:Macleay Press, 2005), 118.

[23] Senator Christine Milne, interview by author, Canberra, Australian Capital Territory, November 1, 2011.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this study is to determine what energy strategies are available to Australia for the next 30 years. This chapter describes the planned research design, how the data will be collected, and how the author intends to compare the various energy options for power generation and transportation. Figure 1 is a visual representation of logic guiding this thesis.

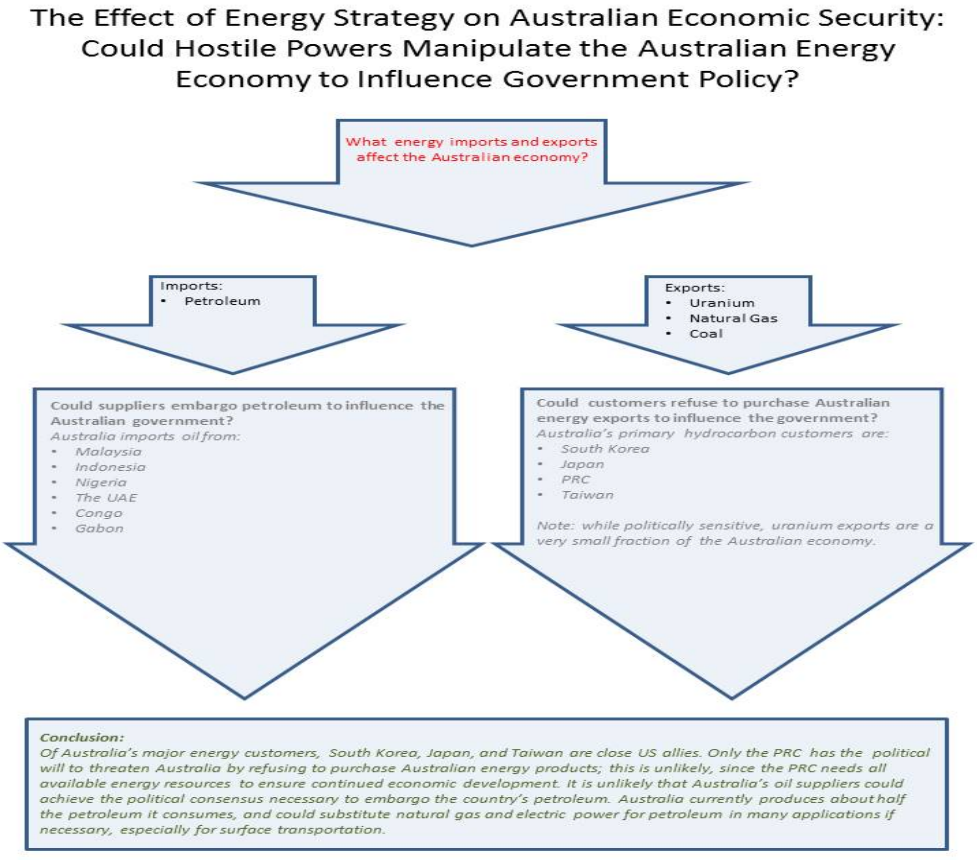

Figure 1. Effect of Energy Strategy on Australian Economic Security

Source: Created by author.

Research Design

To determine energy strategies Australia might pursue, the author will evaluate the primary research question in three parts. The first portion of the study will focus on Australia's current energy environment. This will include fossil fuel and alternative power systems, domestic consumption and foreign exports. The second portion of the study will examine the future energy of the Australian energy economy and likely trends for the next 30 years. The final portion will be the conclusions for the effect of current and future energy policy on the relationship between the United States and Australia. This exploratory study will examine each of the energy sources identified in the first section, focusing on the advantages and disadvantages of each. This last section will examine the possible efficacy of nuclear power in Australia.

Steps to Collect Data

The data collection plan for this thesis to successfully answer the primary and secondary research questions will predominately focus on documentation review of primary and secondary source documents, followed by interviews of Australian politicians and technical experts. This includes historical data, cost data, policies, government reports, and energy production trend data. The author anticipates that interviews with key government and academic researchers will amplify the information uncovered in initial research.

Criteria for Analysis

Criteria in this study will focus on the secondary research questions that answer the primary research question. Ultimately, in answering each of the secondary questions, the study will effectively determine the answer of the primary question.

The criteria for the case study will involve documentation to evaluate Australian energy reserves, production and consumption, and analysis of this data to possible future energy strategies. Data sources will include US and Australian government reports, university studies and online resources. The information gathered will address both the primary and secondary research questions. The results of the case study will examine the current status of Australian energy production and comparisons of possible future alternatives.

The study will evaluate data received from government and industry studies, interviews and press reports using the following criteria:

1. Technical feasibility. Does the current state of the art support the course of action suggested?
2. Economic viability. Is the new fuel or technology competitive in a market economy?
3. Political practicality. Is the energy source acceptable to the Australian electorate?
4. Sustainability. Is the energy source finite (the case in fossil fuels) or renewable (like solar, wind and tidal power)?
5. Supply security. Can the Australian economy rely on the fuel or technology for an uninterrupted supply of energy?

CHAPTER 4

ANALYSIS

The Existing Energy Economy in Australia

There are two types of power generation in Australia. Large-scale centralized power generation found in every industrialized nation services the urban population and industrial centers. Small-scale power generation services sites too remote (and thus, uneconomical) to service using grid power.[1] Due to the remote location of many off-grid systems, precise statistics are not available.

Coal

Figure 2 is a map of Australia's extensive coal deposits. Australia uses domestic coal to generate about 75 percent of electrical power in the country.[2]

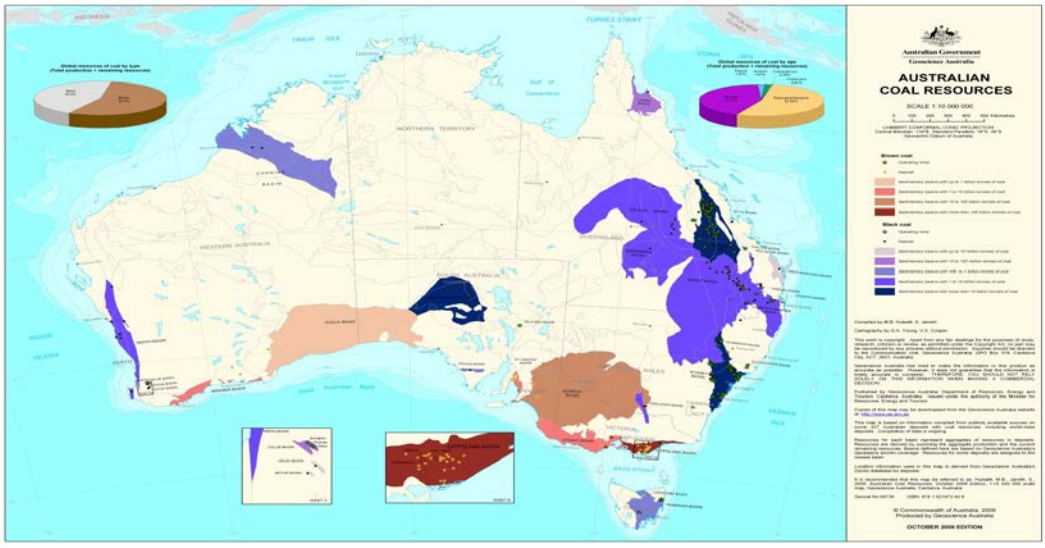

Figure 2. Australian Coal Resources

Source: Geoscience Australia, "Australian Coal Resources" (Canberra: Geoscience Australia, October 2009).

Australian coal varies in quality from brown coal to anthracite. Australian anthracite has a higher net energy content and lower sulfur content than Australian brown coal. In addition to a relatively low energy density, brown coal contains volatiles that can spontaneously combust; both factors make brown coal less suitable to long distance transport. Unfortunately, the volatiles in brown coal tend to create a greater level of pollution when burned, compared to the higher grade black and anthracite coals.[3] Australia uses brown coal primarily for domestic power production.[4] In both Australia and the United States, power plants that use brown coal tend to be located near the mine site to maximize the net energy gained in the process of mining and burning the coal.

As figure 3 demonstrates, Australian coal production far exceeds domestic consumption. The surplus coal available for export has increased dramatically in recent years. Figure 4 shows the relative exports for the top producers worldwide from 2000 to 2009.

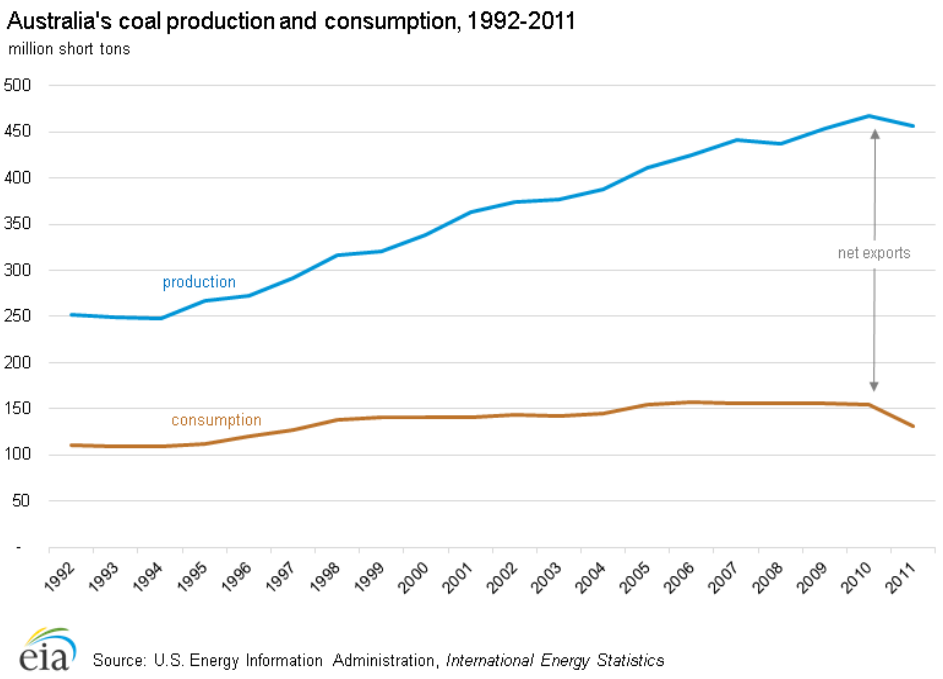

Figure 3. Australia's Total Coal Production and Consumption, 1992-2011

Source: US Energy Information Administration, *Australia Energy Report 2013* (Washington, DC: US Energy Information Administration, 2013), 14.

By revenue generated, coal accounts for over half of Australian energy exports.[5] Australia's largest coal customer is Japan; South Korea, People's Republic of China, India and Europe purchase the remainder.[6] According to the Reserve Bank of Australia, Japan and South Korea purchase coal on long-term contracts with annual price negotiations, while the People's Republic of China tends to purchase Australian coal on the spot market.[7] Following the 2011 tsunami, the Japanese government reevaluated its commitment to nuclear power,[8] which for the near to medium future means that Japan will continue to import fossil fuels to meet its power requirements. Since only two of Japan's 50 nuclear power reactors are in operation as of July 2013, the country will need to import significant quantities of fossil fuel to maintain current generating capacity.

Given Japan's existing relationship with Australia, and Australia's dominant position in the world coal market, Australia is Japan's most likely source for both coal and natural gas. While many countries (including the United States) are transitioning from coal to natural gas for power generation, Australia may choose to continue to export large quantities of gas and continue to use coal to generate electricity.

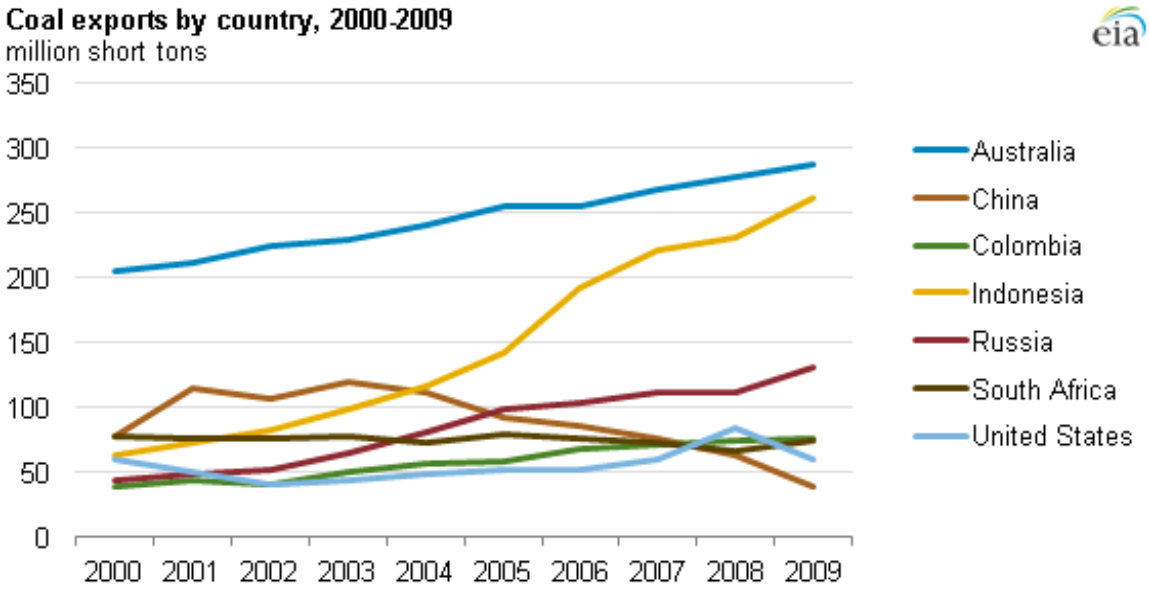

Figure 4. World Coal Exports by Country, 2000-2010

Source: US Energy Information Administration, "Australia World's Largest Coal Exporter, Fourth-largest Liquefied Natural Gas Exporter," November 25, 2011, accessed December 12, 2011, http://www.eia.gov/todayinenergy/ detail.cfm?id= 4050.

Petroleum

Petroleum was first discovered in Australia in December 1953 in Western Australia, near the southern point of the Exmouth Gulf.[9] Historically, Australian

petroleum production started with on-shore fields but as pumping depleted these easily exploited sources, production moved to off-shore fields. Figure 5 is a map of on-shore and off-shore petroleum wells in Australia.

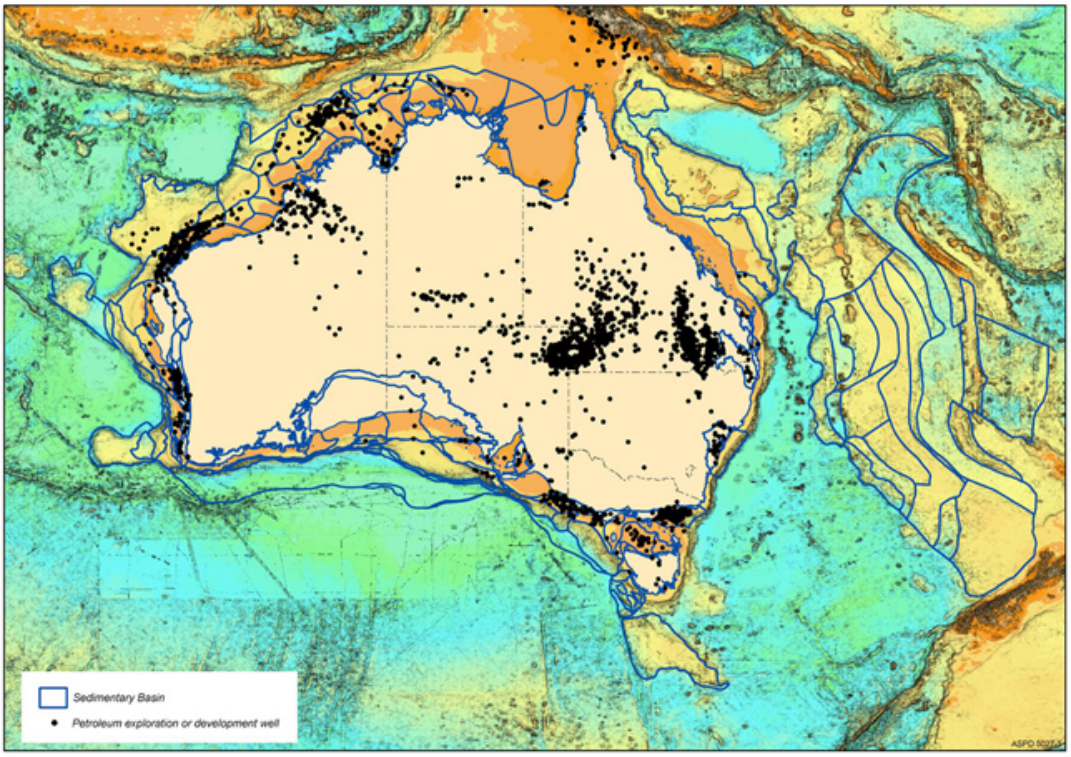

Figure 5. Map of Australia's Off-shore Sedimentary Basins Draped over the Bathymetry and Showing the Location of Petroleum Wells

Source: Geoscience Australia, *AUSGEO News* 77 (March 2005): 9, accessed June 13, 2011, http://www.ga.gov.au/servlet/BigObjFileManager?bigobjid=GA61375).

Australia is a major petroleum producer (588,000 barrels per day in 2009) but due to domestic consumption of 971,000 barrels per day, remains a net petroleum importer. As figure 6 shows, Australia's trends of increasing consumption and decreasing

production required the country to import an increasing share of its oil beginning in 1999.[10] Most Australian crude is light and sweet,[11] requiring minimal refining to produce marketable fuel. Unfortunately, production at both Australia's on-shore and off-shore petroleum fields has declined steadily since its peak in 1967[12] at the same time domestic consumption has increased.

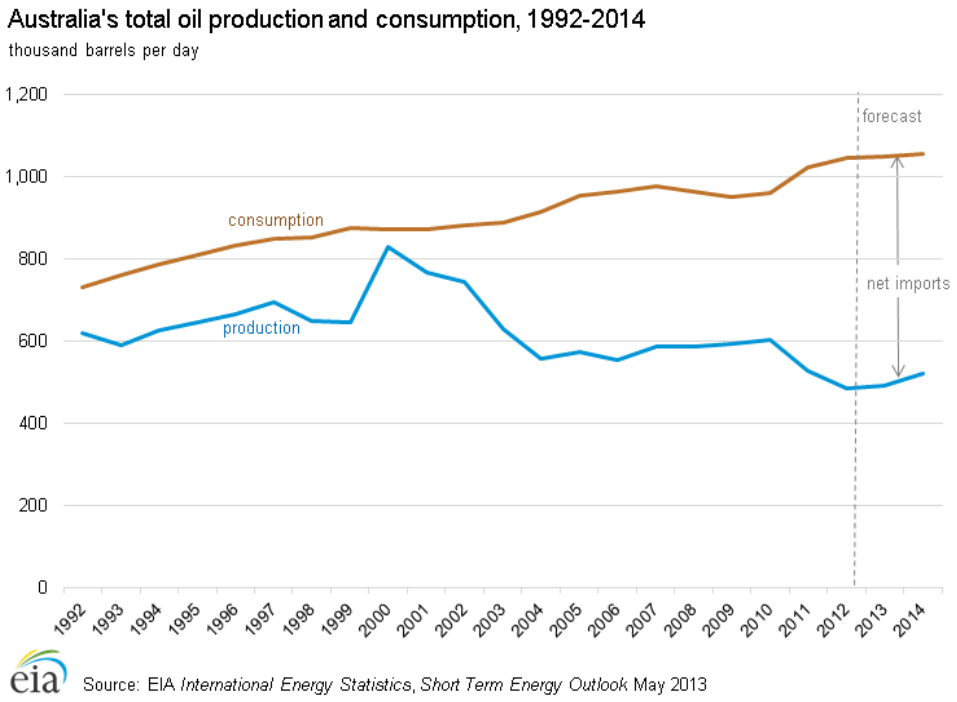

Figure 6. Australia's Total Oil Production and Consumption, 1992-2014

Source: US Energy Information Administration, *Australia Energy Report 2013* (Washington, DC: US Energy Information Administration, 2013), 5.

Australia currently imports roughly half the petroleum it consumes from a variety of Organization of Petroleum Exporting Countries (OPEC) and non-OPEC sources (see figure 7). According to the EIA:

> Singapore supplies about 60 percent of Australia's oil product imports. Most crude oil imports come from Malaysia, Nigeria, United Arab Emirates, and Indonesia, altogether providing about 55 percent of the total imports in 2012. Another 22 percent comes from West Africa, as Nigeria, Congo, and Gabon have increasingly supplied crude to Australia over recent years.[13]

This diversification of petroleum sources could prevent any single supplier from manipulating oil sales to Australia to pressure the government, assuming that the world oil market had sufficient excess capacity to meet the country's petroleum requirements. Appendix G is a brief explanation of OPEC's current composition, and the likelihood that the cartel would embargo Australian oil supplies.

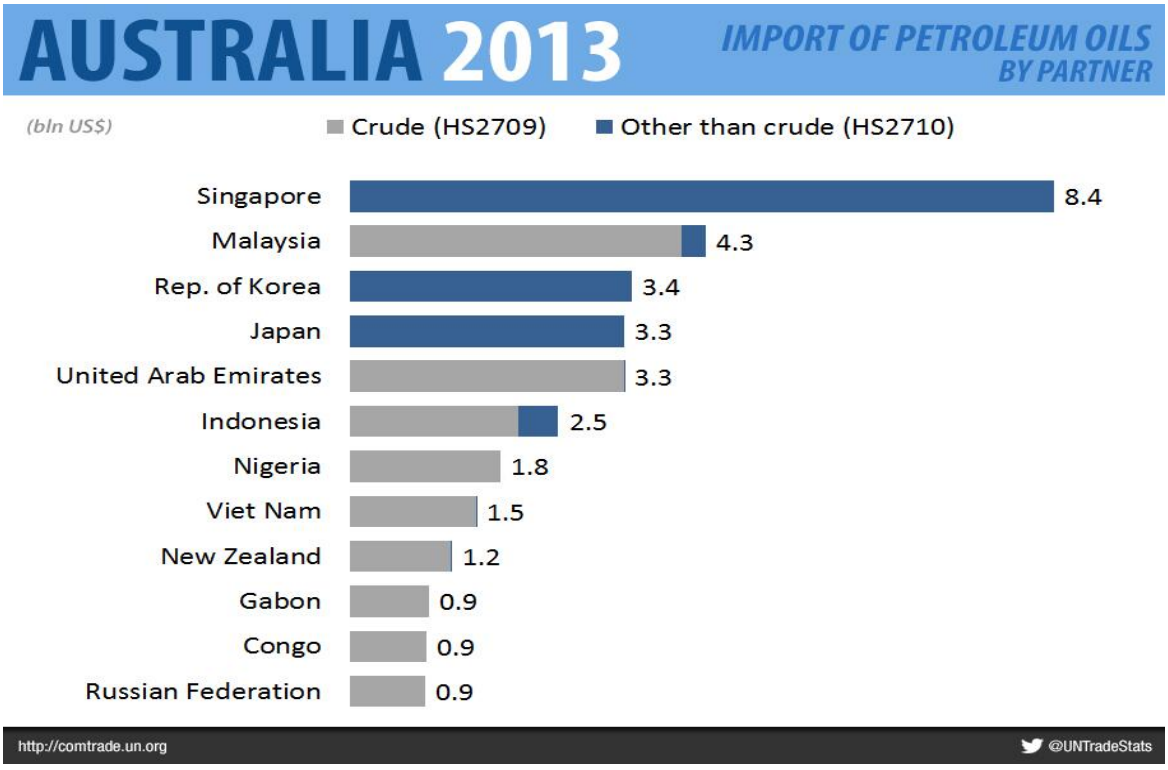

Figure 7. Australian Petroleum Suppliers, 2013

Source: UN Trade Statistics, "Australia 2013, Import of Petroleum Oils by Partner," Twitter, June 17, 2014, accessed 1 July 2014, https://twitter.com/UNTradeStats/status/478968813590175744.

In addition to petroleum, Australia produces fuel from liquid natural gas and condensate. Australia has sufficient natural gas resources to replace petroleum for most light transportation requirements, and natural gas power vehicles are slowly gaining in popularity. If foreign pressure or domestic policy made such a move desirable, Australia could eliminate the need for petroleum imports by substituting domestic natural gas.

Natural Gas

Natural gas is a product of the same geologic and chemical forces that create solid and liquid hydrocarbon fuels. Natural gas is often present in coal and petroleum fields (associated gas) but can also occur independent of other fossil fuels (non-associated gas).[14] Once filtered for contaminants, natural gas is often converted to liquid natural gas to facilitate transportation by cooling to -160 degrees centigrade, which compresses the gas by a factor of 600.[15] Natural gas emits about half the carbon dioxide as coal when burned, making it a preferred fuel to lower greenhouse gas emissions.[16] Natural gas trades most commonly on long-term (greater than one year) contracts. This contrasts strongly with the liquid petroleum market, where short-term price fluctuations are the norm. Australia has an extensive pipeline network between gas fields and the major population centers (see figure 8).

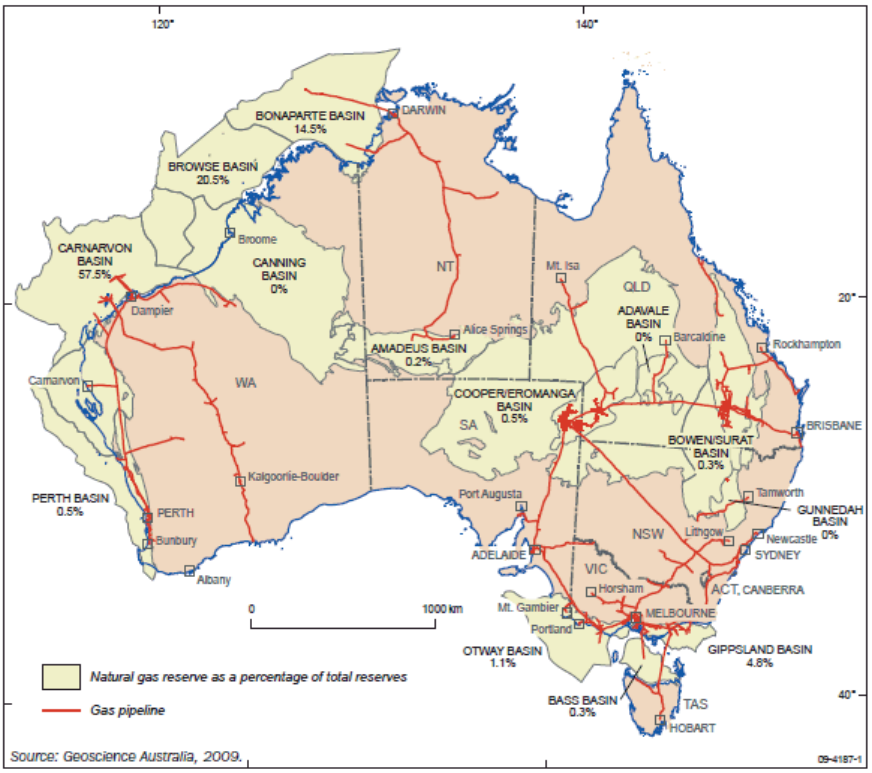

Figure 8. Gas Reserves and Pipelines, January 2009

Source: Australian Bureau of Statistics *2009-10 Year Book Australia* (Canberra: Australian Bureau of Statistics, 2010), 577.

Australia has extensive natural gas reserves, and exported approximately 700 million cubic feet of natural gas in 2010, making Australia the world's fourth largest exporter. Figure 9 shows the country's level of exports compared to other suppliers.[17] As figure 10 shows, Japan is the country's largest gas customer by volume and purchases 70 percent of Australia's natural gas exports; the People's Republic of China, South Korea and Taiwan are other significant customers.[18]

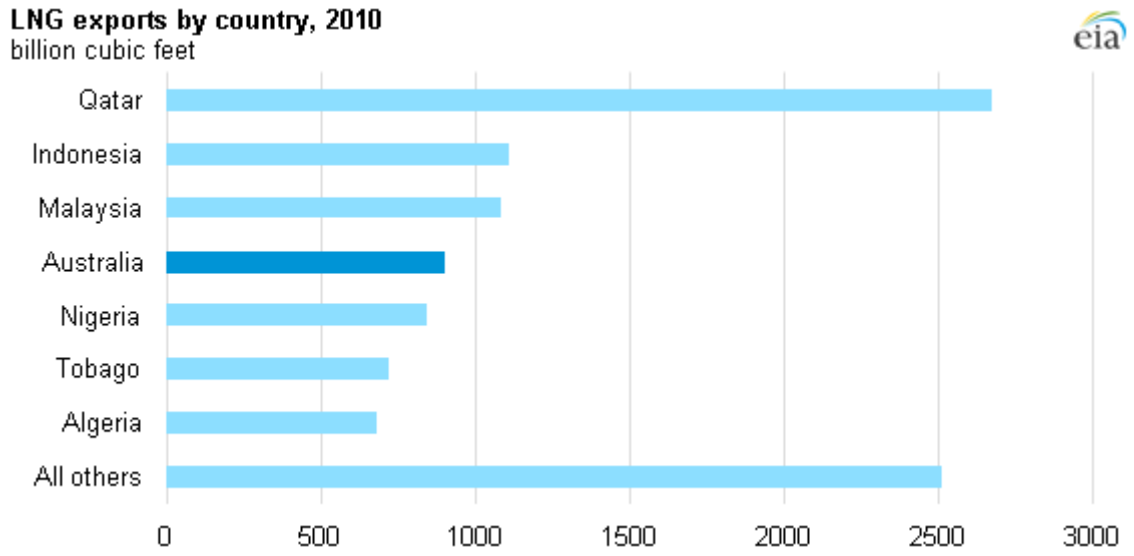

Figure 9. World Liquid Natural Gas Exports

Source: US Energy Information Administration, "Australia World's Largest Coal Exporter, Fourth-largest Liquefied Natural Gas Exporter," November 25, 2011, accessed December 12, 2011, http://www.eia.gov/todayinenergy/ detail.cfm?id= 4050.

Until 1990, Australia consumed all the natural gas it produced; currently, about half of all production is exported.[19] Domestically, Australians use natural gas for much the same purposes as Americans: power generation, domestic heating and cooking, and transportation. In the past several years, Australia began using natural gas as a fuel for mass transit vehicles; in the United States, Compressed Natural Gas (CNG) powers 25 percent of new mass transit vehicles. In late 2006, the New South Wales Transit Authority prepared to introduce CNG powered busses for public transportation in Sydney.[20] Currently the New South Wales Transit Authority runs a fleet of about 2,100 vehicles;[21] of these, 700 are CNG powered.[22] Generally, these CNG powered busses have been well received; unfortunately, one caught fire in July 2011. When video of the incident surfaced the following October, the Sydney mass transit drivers' union went on

strike for one day, claiming unsafe working conditions.[23] In response, the New South Wales Transit Authority removed from service and inspected all CNG powered vehicles in the fleet; all have since been returned to service. While it is impossible to predict the effect this incident will have on natural gas powered vehicles in Australia with certainty, it is unlikely to affect their adoption in the long term, given the success such vehicles enjoy worldwide.

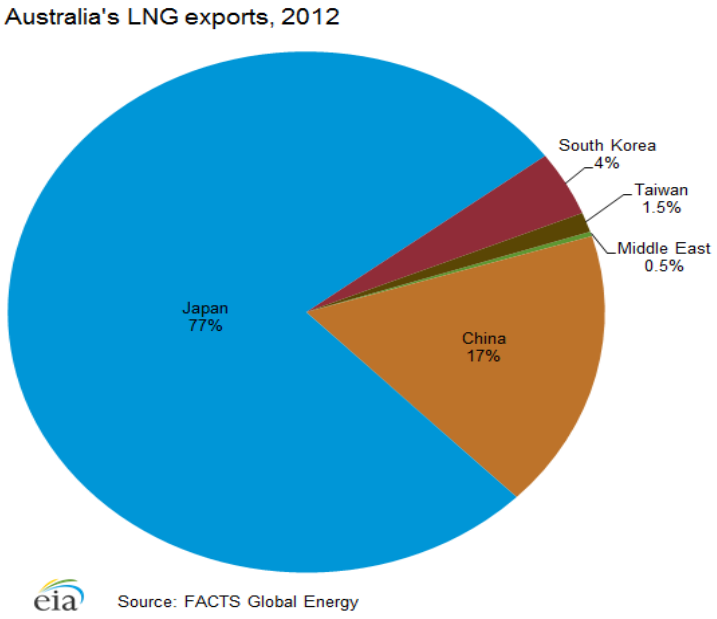

Figure 10. Australia Liquid Natural Gas Exports, 2012

Source: US Energy Information Administration, *Australia Energy Report 2013* (Washington, DC: US Energy Information Administration, 2013), 13.

Unconventional Gas Resources

Natural gas is often found in conjunction with other hydrocarbon fields; the energy industry refers to these natural gas sources as associated supplies. Coal seam gas

(CSG, called coal bed methane in the United States) is present in most coal deposits to some degree. Historically, miners considered this gas a hazardous annoyance; more recently, energy companies have exploited CSG as a fuel. Despite the term coal seam methane, CSG can have a wide range of contaminates, including carbon dioxide and other gases.

In spite of plentiful CSG supplies, CSG exploitation is controversial in Australia.[24] Both citizens and Green politicians[25] have expressed concerns about the environmental impact of CSG. Exploitation often involves the use of hydraulic fracturing (fracking) of the bedrock to maximize the recoverable gas in a field; this can allow CGS and other pollutants to contaminate local ground water.[26] After fracking, most CSG wells also produce water in addition to the gas. In many cases, this water is heavily contaminated and must be processed before being released into the environment, increasing the cost of CSG production substantially.

Similar to CSG, shale deposits close to natural gas fields can also contain commercially exploitable gas. Shale gas exploitation is burgeoning worldwide, particularly in the United States. In 2006, Beach Petroleum began exploring for shale gas northeast of Moomba in the Cooper Basin.[27] In July 2011, the company's first well began producing, making this the first shale gas source in the country. Shale gas production also relies on fracking, leading to the same environmental concerns as CSG. If the technique successfully improves production without damaging the environment, fracking could significantly increase the amount of recoverable natural gas available. Given that exploration has not yet led to commercial exploitation, the Australian public has not reacted to shale gas as an environmental issue yet, but given the worldwide rush to

develop shale gas fields, the issue could become contentious. In February 2014, Western Australia released new regulations to control fracking, and companies soon announced pilot programs.[28]

To date, fracking remains controversial. In May 2014, environment activists prevented METGASCO from commencing fracking operations in New South Wales,[29] while in Kimberley, Western Australia, Buru Energy plans to test fracking on indigenous land with the support of the local population.[30]

Nuclear

The Australian public has been strongly opposed to nuclear power development for decades.[31] This is likely due to a combination of factors, including justifiable concerns over reactor accidents and the perception that the country's abundant coal resources will provide inexpensive power for generations. In 2006, the Howard government commissioned a thorough study of the Australian uranium industry, and the possibility of using nuclear power in the future.[32] However, the effect of the 2011 tsunami on Japanese nuclear power plants effectively ended the nuclear power debate at the national level for the present.[33] In addition to the national consensus against nuclear power, New South Wales,[34] Queensland,[35] and Victoria[36] explicitly outlaw nuclear power facilities.

Australia currently operates the 20-megawatt Open Pool Australian Lightwater research reactor near South Sydney, New South Wales, which replaced the previous High Flux Australian Reactor research reactor in 2006.[37] Australia's ability to operate these reactors safely for decades demonstrates that the country could, if necessary, operate nuclear power stations.

While no domestic market exists, as figure 11 shows, Australia has abundant proven reserves of uranium and thorium, and is one of the world's largest suppliers of uranium for power generation. In 2008, Australia produced 8,500 tons of uranium (almost exclusively for export) [38] amounting to 19.2 percent of the world market.[39] World uranium use has increased roughly 2.8 percent annually; at the same time, the percentage of uranium entering the market from existing stocks (from material salvaged for nuclear warheads and government stockpiles) continues to decrease.[40] Australian companies currently operate three uranium mines: Ranger (Northern Territory); Olympic Dam (South Australia); and Beverly (South Australia).

In addition, Australian companies are in the process of opening two additional mines: Honeymoon and Four Mile, both located in South Australia. The government certified Honeymoon for operation but the mine closed for economic reasons in November 2013.

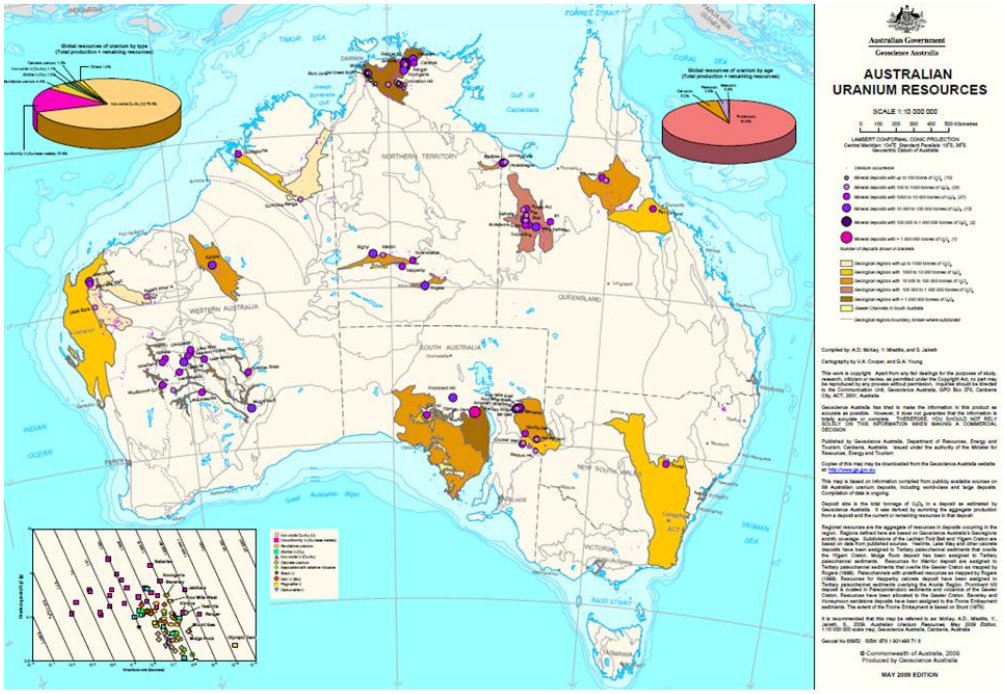

Figure 11. Australian Uranium Resources

Source: Geoscience Australia, *Australian Uranium Resources* (Canberra: Geoscience Australia, May 2008).

Australia refines uranium ore to produce U_3O_8 (yellowcake) for shipment to foreign customers who then further process the material for domestic use or re-export. Australia adheres to the Treaty on the Non-Proliferation of Nuclear Weapons and supplies nuclear material only to customers who also adhere to the treaty and submit to International Atomic Energy Administration inspection protocols.[41]

While Australia continues to export uranium, Australian politicians are well aware of the policy dichotomy between domestic and foreign use of fissile material. Senator Milne (Green Party) would prefer to stop all mining, processing and export of uranium immediately,[42] while Senator Abetz (Liberal Party) sees no issue with prudent

nuclear energy development in Australia.[43] These views occupy the extremes of current social and political opinions in Australia; both senators acknowledge that public opinion is unlikely to favor either an outright ban on uranium mining nor nuclear power development in the foreseeable future. Should public opinion change, Australia has sufficient economic resources to build nuclear power facilities and ample domestic supplies of uranium for fuel.

Hydroelectric

Hydroelectric power is highly desirable as a non-carbon emitting energy source. Unfortunately, the nature of Australian geology, which consists of a narrow strip of well-watered land along the coast and a very dry interior, has limited opportunities for hydro-electric power generation. The exception to this is Tasmania, where 86 percent of the power generation is hydroelectric;[44] Tasmania began using hydroelectric power in 1895.[45] The 3,800-megawatt Snowy Mountains Scheme uses water from the Murray and Murrumbidgee river systems.[46] Snowy Mountains supplies power to Sydney, Brisbane, Canberra, Melbourne and Adelaide via eastern national grid. [47]

Unfortunately, the Green party (which wields considerable power at the state and national level) is adamantly opposed to expanding existing hydroelectric facilities or creating new ones.[48] Given the current political climate, it is unlikely that Australia will expand its use of hydroelectric power in the near future.

Wind

Wind power is currently one of the technologies of choice for both remote site power generation and as a renewable source for conventional power systems. Australia's

embrace of wind power is a legacy of the nation's long use of wind power to pump water for agricultural and human consumption. Wind accounts for only 1.5 percent of electricity production nationwide; by 2030, this will likely rise to over 10 percent of power production.[49] Several geographic and political factors make wind power highly attractive in Australia. First, wind power produces minimal greenhouse gasses during manufacture and none during operation. Second, as a nation with a large coastline, Australia has extensive areas suitable for wind farms.

Off-shore wind farms offer several advantages. The littoral seas are wholly owned by the national government, which eliminates the cost of purchasing or leasing land from current owners. The cost of transporting large assemblies such as wind turbines by water is lower than the cost of land transport, and less disruptive of the road network. While off-shore wind turbines require an anchor to the sea floor, this requires less infrastructure than building a foundation that can withstand the dynamic forces the wind imparts on a rigid structure. The United Kingdom recently finished the London Array, the world's largest off-shore wind farm. Anchored off the shore of Kent, the Array consists of 175 turbines and can produce up to 630 megawatts. Given the high carbon tax in Australia (four times the rate in Europe as of July 2013);[50] zero-emission wind farms are an even more attractive energy solution in Australia.

Unfortunately, wind farm workers have found small numbers (approximately 18) Wedge Tailed Eagles that died after striking the turbine blades.[51] An unknown number may have also been injured. This seems to be a common problem with wind turbines and causes some controversy among environmentalists;[52] experts argue that proper wind turbine design and placement will minimize environmental impact.[53] While wind turbines

kill a small number of birds in Australia, the fact that the turbines negatively affect wildlife in any way is antithetical to the Greens' position on wind turbine power.

Solar (Electric and Thermal)

Solar energy falls into two broad categories: solar energy used to heat water for domestic use and solar energy used to generate electrical power. Solar electric power is further divided into photo-voltaic technology, where sunlight is converted directly into electricity using semiconductor arrays, and solar-thermal systems that use mirrors to concentrate sunlight to heat a working fluid (usually water). The heat from this working fluid then drives a conventional thermal plant, the only difference being that energy source is sunlight rather than fossil fuel, geothermal or nuclear reactions.

Interviews indicate that the use of sunlight to heat water for domestic use is commonplace in Australia, especially in remote areas. However, due to the non-billable, non-taxable nature of such installations, no reliable figures exist for the number of homes that use such systems.[54]

Small-scale Power Production

Numbers are difficult to estimate, but approximately five percent of electricity produced in Australia is non-grid (produced from sources other than a central power company); this small but significant market includes remote ranches and small communities. The small-scale consumers use a variety of means to meet their electricity requirements, including petroleum (gasoline and diesel) generators, wind power and solar photovoltaic arrays; the *Energy White Paper 2012* proposes a national level strategy to provide all potential customers with grid power.[55]

Given the existing state of the art, solar photovoltaic systems are often the best choice for small-scale producers, assuming that local weather conditions allow for sufficient available sunlight. Solar photovoltaic systems have considerable advantages for the small-scale producer. Unlike wind turbines, solar systems typically have no moving parts; this can be a considerable advantage in areas where airborne grit is common.

Regardless of the method of producing power, storage is vital, especially in wind and solar generation system. Battery technology continues to advance, but anecdotal evidence indicates that most independent power producers continue to rely on proven technologies, particularly deep-cycle lead-acid batteries.[56] In contrast to battery systems for transportation, cost and not weight is the driving factor for home built power systems, and lead-acid technology requires little maintenance and remains highly durable.

The Australian Energy Market Commission Reliability Panel monitors the National Electricity Market (NEM) customer base with the goal of reducing the number of off-grid customers below .002 percent of the total power used in the NEM region.

Australian Energy Distribution Systems

The Australian Power Distribution System

Currently, Australia has no unified national power system in the same way the United States does. Australia began the NEM project in December 1998 to connect the entire east coast onto one system from Port Douglas in Queensland to Port Lincoln in South Australia, a distance of over 2,400 miles. Currently, there are five separate grids in the country:[57] the NEM; the Northwest Interconnected System; the Southwest Interconnected System; the Darwin-Katherine system; and the Alice Springs system.

In April 2006, Tasmania joined the NEM grid via the second longest submarine power cable in the world.[58] Due to the distances involved (especially in Western Australia) and relatively small demographics, the Northern Territories and Western Australia are unlikely to join the NEM in the near future. In addition to these three independent grids, some communities in the interior (Alice Springs, for example) generate power independent of the major regional systems. Figure 12 is a map of the Australian power distribution system.

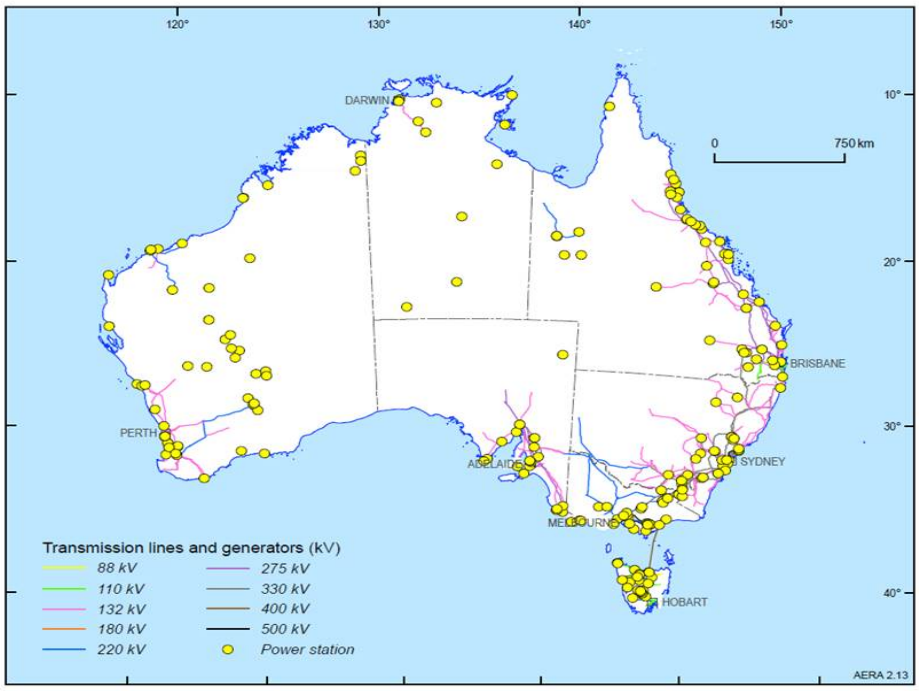

Figure 12. Australia's Electricity Infrastructure

Source: Australian Department of Resources, Energy and Tourism, *Australian Energy Resource Assessment* (Canberra: RET, May 2010), 24.

The Green party seeks to create a smart grid nationwide. Smart grid systems consist of the power distribution network that operates in conjunction with an extensive array of sensors to monitor power production and consumption. Such an electrical distribution network would allow for computer controlled power monitoring and redistribution. While not, strictly speaking, necessary for a green energy economy, a smart grid greatly improves the viability of intermittent renewable energy sources such as solar photovoltaic and wind generation by monitoring energy use to ensure available resources are distributed most effectively.[59] The government of Australia is currently promoting a nationwide broadband fiber optic internet system that would be an ideal communication media for the smart grid control network.[60]

The Australian Pipeline System

According to the US Department of Transportation, long distance natural gas pipelines are the safest transportation method in the United States.[61] Considering Australia's level of development and commitment to environmentally friendly, sustainable development, one can extrapolate that pipelines are the safest and most cost effective way to move liquid and gaseous hydrocarbons from the wellhead to processing and export facilities. Currently, Australia has approximately 25,000 miles of pipeline installed.[62] As figure 13 shows, these networks tend to run between the country's major population centers (generally along the coast and from the Darwin metropolitan area to the vicinity of Alice Springs and Ayers Rock in the Northern Territory) and from the off-shore oil and gas fields to the mainland. In 2002, a 753-kilometer undersea natural gas pipeline joined the Tasmanian and Victorian natural gas systems.[63]

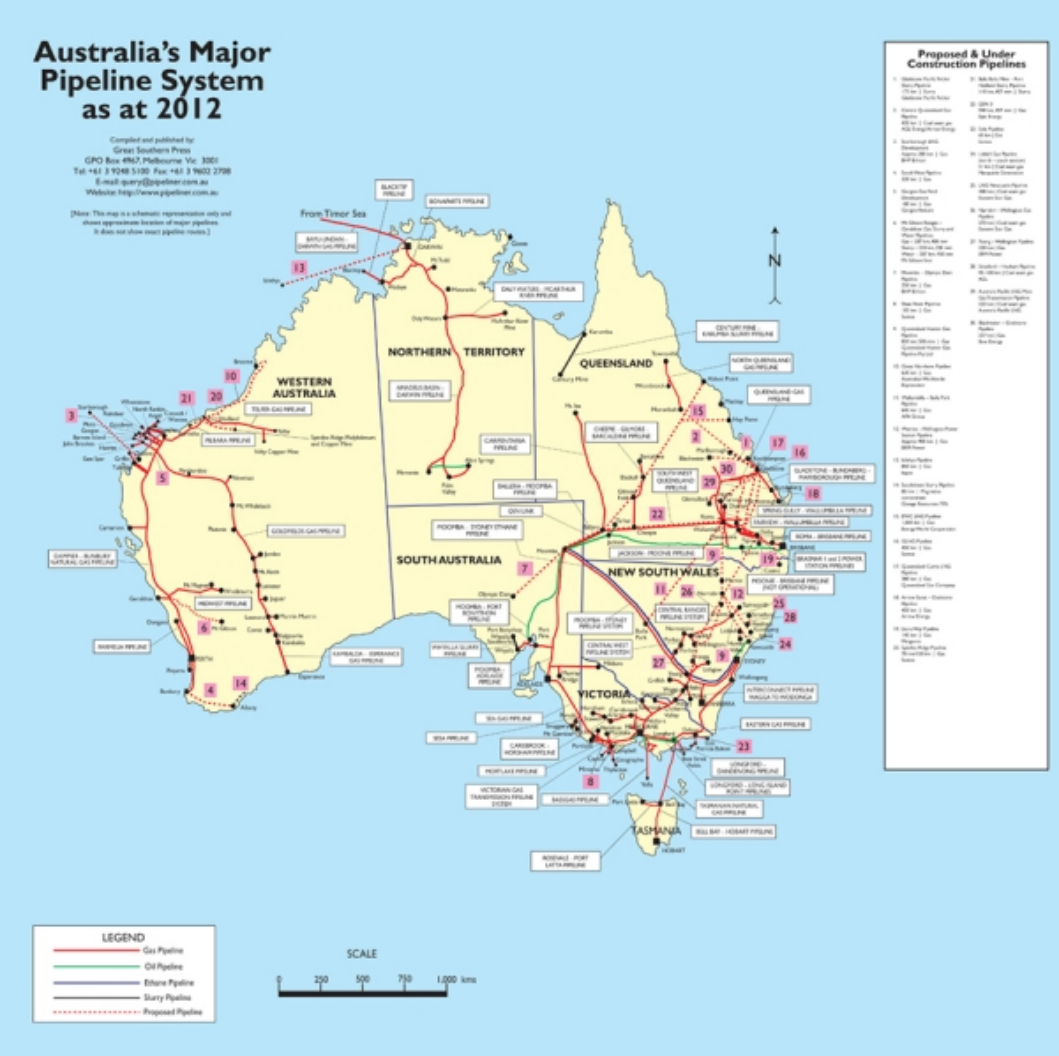

Figure 13. Australia Major Natural Gas and Petroleum Pipeline System, 2012

Source: Great Southern Press, *Australia's Major Natural Gas and Petroleum Pipeline System as at 2012* (Melbourne: Great Southern Press, 2013).

While Australia's pipeline safety record is superior to that in the United States (as measured by the number of annual incidents per length of pipeline),[64] on June 3, 2008 Australia suffered a major blowout of the Varanus Island Pipeline, which supplied one-third of the natural gas used in Western Australia. Apache Energy, which operates the pipeline, was unable to restore full capacity until December 2008. The resulting

economic disruption severely affected Western Australia, forcing businesses to scale back or curtail operations for the duration of the crisis.

The Effect of the Kyoto Protocols on Australia

The Australian government signed the Kyoto Protocols in 1997, and ratified them in 2007.[65] In November 2012, the Gillard administration committed to the next phase of the agreement, which requires Australia to reduce greenhouse gas emissions from 2013-2020 to below 95 percent of Australia's emissions in 2000. In spite of the Australian Parliament's July 2014 repeal of the Carbon Tax Law, the country remains committed to meeting these goals as a matter of public policy at this time.

The Kyoto Protocols affect Australia in two direct ways. First, the protocols will force the country to significantly reduce greenhouse gas emissions. Since Australia generates most of its electricity using coal, Australia will need to find alternative, non-hydrocarbon burning sources of power. Australia has considerable natural gas supplies but a natural gas fired power plant still produces considerable CO_2, which rules out natural gas as an alternative to coal. The interior of the country is arid, limiting the possibilities for additional hydroelectric power generation. Wind, geothermal and solar energy (as well as developmental clean energy technologies such as wave power) can supplement existing plants but until effective storage technologies are affordable on a large scale, these technologies are too inconsistent for baseline power generation.

Second, the protocols will limit the external market for Australia's energy products, as current customers reduce their use of fossil fuels to comply with Kyoto guidelines. Since Australia earns considerable foreign exchange from the sale of fossil fuels, this shift will inevitably affect the country's economy.

There is a third, indirect effect: the public pressure to curtail overseas fossil fuel sales. There is an inherent contradiction between reducing the domestic use of fossil fuels and selling these fuels overseas; public pressure could force the government to curtail these exports.

Even before the Carbon Tax became law, the opposition parties promulgated the Direct Action Plan (DAP) of 2010[66] as an alternative carbon control scheme. The Australian Parliament voted to repeal the Carbon Tax laws in July 2014; the Coalition government now uses the DAP as a blueprint for carbon dioxide reduction.

The DAP affirms the Australian government's commitment to reduce carbon emissions below 95 percent of 2000 levels by 2020 but uses incentives rather than punitive taxes to achieve the goal.[67] Central to this effort are bio-sequestration of carbon and an Emissions Reduction Fund (ERF). As described in the plan: "The single largest opportunity for CO2 emissions reduction in Australia is through bio-sequestration in general, and in particular, the replenishment of our soil carbons. It is also the lowest cost CO2 emissions reduction available in Australia on a large scale."[68] A key component of bio-sequestration is the Abbott administration's plan to plant 20 million trees as a carbon sink at the public's expense.

The ERF is a federal-level government program to provide the resources necessary to migrate to less carbon intensive technologies. According to the Australian Parliament's Budget Review 2014-2015, the ERF is not a grant system but effectively functions as such, since ERF recipients will not repay the money received.[69] The Australian government plans to allocate 2.55 billion Australian dollars for the ERF and will select which projects to fund in a reverse auction.[70] In this system the government

will set a maximum price for a given emission reduction goal; interested parties will then submit proposals, the lowest of which wins the contract.

Other DAP programs include Solar Cities, an incentive plan to increase the use of photovoltaic and thermal solar systems, support for the world's largest carbon capture facility in Western Australia (scheduled to begin operation in 2015)[71] and continued support for the Mandatory Renewable Energy Target plan to produce at least 15 percent on the country's power using low emission technologies.[72]

Some climate scientists remain unconvinced that the DAP can achieve the desired effect. Australian climate specialist Tim Lubcke argues that the DAP relies on overly optimistic projections of tree planting, and calculates that in order to be effective, bio-sequestration would require "Australian wood supply to increase by an additional 300% and require high quality land twice the size of Melbourne which does not already provide natural sequestration."[73] Other climatologists share Lubcke's concern with the efficacy of carbon capture schemes; in a December 2008 paper, US Geologic Survey scientists concluded that different climate change models produce completely different predictions of carbon sequestration effects.[74]

Lubcke also argues that the ERF will essentially be a taxpayer funded subsidy for carbon intensive industries. Lubcke is correct in stating that the ERF is essentially a publicly funded grant to polluting industries, but fails to recognize that the industries that paid the Carbon Tax passed the cost on to their customers (in the case of the power industry, the majority of homes and businesses in the country) and created an additional bureaucracy to administer the tax.

Since the Abbott administration took office, its environmental policies have proven nearly as controversial as the previous administration's Carbon Tax. The DAP remains a work in progress; only time will prove if the DAP will allow Australia to meet its carbon control goals by 2020.

The Future Energy Economy in Australia

Coal

Most large economies in the world (including the United States, the People's Republic of China, Japan and Australia) rely on coal, primarily for power generation and, to a less degree, as a fuel for industrial processes such as smelting ore. The environmental impact of coal consumption is a factor of both the quality of the fuel and the method of combustion. Any hydrocarbon fuel can burn cleanly; the only question is the cost of removing the contaminants from the fuel before it is burned or from the resulting exhaust. Natural gas is pure hydrocarbon at the point that a customer receives the fuel; this virtually eliminates the need for post-combustion processing to remove pollutants. In contrast, post-combustion stack gas can contain a wide variety of pollutants, ranging from sulfur compounds to heavy metals (especially mercury) depending on the quality of the coal. The current political trend in Australia favors technologies that reduce pollution. This will increase the move towards natural gas at the expense of coal as a fuel for power production, and possibly transportation.

These factors suggest a gradual decrease in Australian coal exploitation, both for domestic production and export. It is possible that Australia could find alternative markets for its coal, but this becomes less likely as industrialized economies turn to clean

energy solutions. Assuming world natural gas consumption continues to grow, natural gas could replace coal as Australia's primary energy export.

All of the above assume that Australia continues to use conventional combustion plants to produce electricity, but a new technology could make coal an attractive option. In March 2013, the Ohio State University announced a new process that extracts energy from coal without combustion.[75] In a program funded by the US Department of Energy, Ohio State chemist Liang-Shih Fan developed a process that releases energy by heating pulverized coal in a sealed reactor with an iron-based catalyst. The only byproducts of the process are carbon dioxide and water vapor; the iron catalyst is reusable after processing. This process would eliminate many of the highly toxic pollutants that standard combustion produces, including mercury and sulfur compounds. A proviso of the Department of Energy funding was that the process would not raise the price of resulting electricity by more than 35 percent.[76] If this process is scalable, it could make even low-grade coal a viable, low polluting option for power generation in Australia.

Petroleum

Current and recent historical trends indicate that Australian petroleum production will gradually decrease as exploitation depletes existing fields. [77] Like the United States, Australian petroleum consumption is likely to increase in the future. Most Australian politicians and technical experts consulted opined that a gradual increase in electric vehicles will offset the decrease in domestic petroleum production, and thus prevent a fuel crisis.[78] The exception to this was Senator Milne (Green Party), who felt that Australia should immediately move to a combination of electric powered vehicles and public transportation.[79]

While intriguing, several hurdles stand in the way of Senator Milne's proposal. First, Australia produces about 75 percent of its electricity from coal— including brown coal. Brown coal has a lower energy density than black coal, meaning that more of the material must be extracted, transported and burned to produce the same amount of electrical power. When burned, brown coal also produces significantly more ash than black coal.[80] Unless Australia replaced many of the existing coal-fired power plants with some form of non-polluting generation, switching to electric vehicles would do little to reduce the overall level of air pollution in Australia. Furthermore, the current Australian power gird might require additional capacity to carry sufficient power for the replacement electric vehicles. These factors argue for an evolutionary introduction of electric vehicles vice a revolutionary one. See Appendix D for a discussion of the conversion of the existing Australian light vehicle fleet to electric power.

Natural Gas

All data indicate that Australia will increase natural gas exploitation for both domestic and export consumption. Australia's primary natural gas customers (Japan, the People's Republic of China and South Korea) all rely on natural gas as both a source of clean energy and as feedstock for the production of chemical products. As the attention of developed and developing economies turns from traditional coal-based power to cleaner sources, the world market for natural gas is likely to increase for the foreseeable future.

Given the realities of the Australian petroleum economy (gradually decreasing production coupled with increasing imports to meet consumer demand), natural gas would make an excellent substitute to meet the country's need for transportation energy, especially in areas were battery powered vehicles are impractical. Once natural gas is

prepared for the market, it consists of almost pure hydrocarbon. The byproducts of natural gas combustion are almost entirely carbon dioxide and water vapor.

Several developing countries (including India, Pakistan and Brazil) already have an expanding base of vehicles powered by CNG. Worldwide, the number of CNG powered vehicles expanded from one million to five million between 1996 and 2006.[81] Australia is well prepared to replace petroleum with natural gas, and already has a robust CNG industry and about 2,000 refueling sites.[82]

Geothermal

Geothermal power production depends on the exploitation of the natural heat of the Earth deep underground. While the temperature rises as one drills deeper anywhere on the Earth's surface, not all bedrock is suitable for geothermal power generation. Commercially viable geothermal energy production requires an exploitable layer of hot, non-porous rock. Fractured bedrocks and porous rocks such as limestone would tend to allow the working fluid (generally water) to dissipate.

The Olympic Dam site in South Australia has excellent potential for geothermal production. The bedrock consists of hot, homogenous granite, and the site is located within 10 kilometers of the NEM grid. Studies indicate that the site could produce 2,160 petajoules of power over a 30-year period.[83]

Geothermal power generation would appear to be ideal for Australia's growing energy requirements. The system has negligible carbon emissions while under construction and no carbon emissions at all during operation. Assuming sufficient suitable bedrock is available, geothermal systems are scalable to meet expanding energy requirements.

Nuclear

Given the current political environment, Australia is highly unlikely to develop any uranium or plutonium fueled power plants based in the foreseeable future. This is due to both popular social pressure against such development, and political pressure from Green party politicians at the state and national level.[84] For these attitudes to change, Australia would have to suffer a major energy crisis, which is unlikely given the huge coal and natural gas reserves in the country. Only the deployment of practical nuclear fusion (under development for decades, and still incapable of extracting more energy than the process consumes) might affect this political equation.

Nuclear proponents often cite thorium based technologies as an answer to nuclear power concerns (especially proliferation), and claim that a thorium-uranium fuel system does not breed plutonium. Thorium is far more common in the Earth's crust than uranium, and Australia has plentiful reserves. As it is found in nature, thorium is not a suitable nuclear fuel and must receive neutrons from an external source (typically uranium 233) in order to transmute into usable fuel. While thorium proponents are correct in asserting that a thorium fuel cycle does not breed large quantities of plutonium; unfortunately, it does breed fissile uranium 233.[85] Given a sufficient level of enrichment, U-233 could be used to build a nuclear weapon.

The United States experimented with a combined thorium-uranium fuel cycle concept in the 1960s, and successfully operated reactors for years.[86] In spite of early promising results in several countries, only India pursued thorium technologies.[87] In late 2012, India announced it would break ground on a thorium-fueled power plant in 2013;

given the protracted nature of nuclear plant construction, it will be several years before India will be able to demonstrate this technology.[88]

Thorium based technologies remain controversial. Amory Larson writes that thorium reactors breed fissile material with weapon potential in the same manner as more common uranium reactors, and argues against thorium fuel as a safer alternative to uranium or plutonium.[89] In their May 1979 rebuttal of Larson's article, Frank von Hippel and Robert H. Williams argue that if used in a once-through fuel cycle (where the spent reactor fuel is not processed to re-use) spent thorium is no more prone to weaponization than low-grade uranium.[90] Von Hippel and Williams also assert that Larson is mistaken in stating that spent thorium fuel requires reprocessing.

Molten salt reactors (MSR) could be an attractive alternative to conventional solid fuel fission reactors. The United States developed and operated experimental MSRs fueled with uranium and thorium salts between 1954 and 1969.[91] For various reasons unconnected to proliferation concerns, India, the People's Republic of China, France and the United States are researching thorium fueled MSRs, which have several advantages of existing uranium and plutonium technologies. First, as mentioned above, thorium is more plentiful than uranium in the Earth's crust. Second, as the fuel in an MSR heats, it becomes less dense and cools down, making the MSR thermally self-regulating.[92] While initial projections are promising, MSR technology is over a decade from commercial viability, assuming that the interested parties are able to solve the technical challenges of thorium reactors.

Biofuels

The term biofuel covers a wide range of solid, liquid and gaseous hydrocarbons. Gasoline blended with ethanol (usually derived from corn) is the most familiar in the United States. Australia also uses blended fuels; these range from E5 (five percent ethanol, 95 percent gasoline) to E85 (85 percent ethanol, 15 percent gasoline). E85 is slowly becoming more common as the availability of vehicles designed to run on a variety of ethanol blends increases. While ethanol blends have a similar viscosity to gasoline, a vehicle's fuel system must be specifically designed to carry alcohol-based fuels or the ethanol can cause damage.[93] Currently, E10 is the most common blended fuel available in Australia; the Australian government judges that this fuel is safe to use in older vehicles that were not designed to use an alcohol-based fuel.[94]

Biomass is another form of biofuel that includes waste material from agricultural production as well as wood-based waste such as wood chips and saw dust.[95] Some Australian coal-fired power plants already burn biomass to both eliminate waste and reduce the cost of power. In 2008, biomass produced about two terawatt-hours of electricity in Australia; this represents a small percentage of the electricity produced in the country, but the Australian government expects this amount of power generated using biomass to grow by 2.2 percent annually through 2030.[96]

Wave and Tidal Power

Australia's extensive coastline is an ideal environment for wave and tidal power systems. Like wind and solar power, wave and tidal systems have a low impact on the environment, and produce no carbon emissions while in operation. Unlike wind and solar systems, wave and tidal systems are more predictable. Wave systems will generate power

around the clock, while tidal systems will create power at all times except during the relatively short extreme high and low tide periods.

Like any engineering concept, wave and tidal systems have some limitations and drawbacks. While the tides are highly predictable, the waves are not and can be quite violent, depending on the weather. In addition, the marine environment is highly corrosive and is home to a number of animals (such as barnacles and corals) that will colonize any available surface, potentially fouling any moving components. These factors require engineers to design highly robust systems to ensure that such systems are economically viable.

Australian Energy Customers and Energy Exports as a Political Weapon

The Central Intelligence Agency estimates that the Australian Gross Domestic Product in 2012 was just under one trillion US dollars.[97] Australia exports about 260 billion dollars in goods; the People's Republic of China is their primary customer, purchasing about 30 percent.[98]

According to the US Energy Information Administration, Australia is a net energy exporter and is self-sufficient in all fossil fuels except petroleum.[99] The Reserve Bank of Australia reports that energy exports are a major factor in Australian economy, with coal accounting for six percent of exports by value.[100] Australia was the world's second largest coal exporter in 2011 and the third largest liquid natural gas exporter in 2012.[101] Because of the importance of energy exports to the Australian economy, a hostile customer could potentially attempt to influence Australian policy by manipulating energy purchases.

Australia's primary energy customer is Japan, which imported about 40 percent of Australian coal exports and about 77 percent of natural gas exports in 2012.[102] Given the current foreign engagement uncertainties Japan faces with North Korea (which detonated nuclear devices with little warning [103] and launched long-range missiles over Japan)[104] and the People's Republic of China (which is embroiled with Japan over the disputed sovereignty of the Senkaku islands)[105] it is unlikely that Japan would abrogate existing energy contracts with Australia as a political weapon. This would certainly antagonize the United States, a close ally of both nations that Japan relies upon to guarantee its national security.

Practical issues would also affect any Japanese decision to curtail fossil fuel import from Australia. The 2011 tsunami disabled several nuclear power reactors in Japan; Japanese public opinion may not allow new nuclear plants to replace those lost. Since a nuclear power plant takes between five and 10 years to complete, Japan is effectively locked into a fossil fuel strategy for the medium term. Japan is likely to remain a predictable energy trading partner for some time in the future.

South Korea is another significant customer of Australian coal and natural gas, purchasing about 20 and four percent of exports, respectively.[106] Similar to Japan, South Korea relies on a strong relationship with the United States to counter frequent threats from North Korea. Given South Korea's smaller share of Australian energy exports and dependence on the United States for its defense, it is unlikely that South Korea would attempt to leverage energy imports as a foreign policy tool.

Of all countries that purchase Australia's fossil fuel exports, only the People's Republic of China is in an economic, political and military position to uses its power as a

consumer to pressure Australia. The PRC purchases 14 percent of Australian coal exports (double the amount imported in 2009) and 17 percent of natural gas exports.[107] This makes Japan a more important energy trading partner to Australia than the PRC, in spite of the latter's larger economy.

The PRC affects the Australian energy market in two major ways: as a customer (in competition with other export consumers) and as an investment partner. According to the US Energy Information Administration: "All three main Chinese national oil companies (NOCs) have teamed with international oil companies (IOCs) on several Australian liquefaction projects and signed gas purchase agreements to lock in supply for the growing market in China."[108] This gives the PRC leverage in the Australian energy market as shareholders but this influence is a double edged sword: if the PRC operates in a manner that is detrimental to Australia's commercial interests, it risks losing considerable equity.

The tremendous size of the Chinese economy relative to Australia's gives the PRC some leverage as a customer of Australian coal and natural gas. However, China seems to follow a national political and energy strategy designed to assure economic growth. The country's publically released energy policy favors rapid development of fossil fuel, nuclear and hydroelectric power, with a gradual shift to alternative energy sources. To use energy as a tool to influence Australian government policy, the PRC would need to find alternative suppliers for its coal and natural gas requirements—who may not be forthcoming, depending on the state of the international energy market at the time.

Chinese energy contracts support this view; the PRC negotiates long-term (five to 30-year) natural gas contracts with foreign suppliers[109] but tends to purchase Australian coal on the spot market.[110] These contracts support the Chinese government's publicized energy policies, which direct a switch from older, heavily polluting coal-fired electric plants (which currently produce 80 percent of the power in the PRC)[111] to a balanced energy economy using petroleum for transportation and a mix of natural gas, renewable energy and nuclear power for electricity.[112]

Given the global growth of the natural gas market, Australia could find alternative customers for its exports should the PRC decide to abrogate or not renew existing contracts. The long-term nature of natural gas contracts would give Australia the time necessary to negotiate these agreements should the PRC refuse to purchase future production.

Australia and China negotiate coal contracts more frequently,[113] giving Australia less time to find replacement customers. Fortunately for Australia, the PRC purchases a smaller fraction of Australian coal exports than Japan (Australia's largest coal customer).[114] According to the EIA, Japan purchased additional coal to replace the electrical capacity lost by nuclear plants destroyed in the 2011 tsunami.[115] Assuming the Japanese power industry chooses to replace these with new nuclear plants, Japan will still need the additional coal for at least another decade—and Japanese public opinion may not favor new nuclear plants.

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CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The political power of the mining industry and unions and the foreign exchange fossil fuel exports bring to the economy make it unlikely that Australia will significantly reduce exports. Given the growing need for energy worldwide, it is unlikely that Australia will lack energy customers in short to medium term. Sales of nuclear fuel to foreign customers are a matter of concern for some legislators but do not seem to have the same resonance with the public as fossil fuel pollution.[1] Given these factors, Australian energy exports are likely to remain a reliable source of foreign exchange for the foreseeable future.

Potentially, an adversary could attempt to influence Australia using the county's energy imports or exports in one of three ways. Australia's customers could refuse to buy Australian energy products, Australia's petroleum suppliers could refuse to sell the country oil products, or a hostile power could try to blockade the country.

Japan is Australia's primary coal and natural gas customer.[2] Given the effects of the 2011 tsunami on the Japanese power industry, Japan is unlikely to discontinue importing fossil fuel from Australia in the near to medium future. Even if Japan made an immediate decision to switch to more extensive use of nuclear power generation, the country would require over a decade to fully implement the policy (see Appendix C for an explanation of the nuclear plant construction cycle). In this event, increasing demand on the world energy market would still allow Australia to find other export customers for its fossil fuels.

A similar situation exists for Australia's other energy consumers. India, the PRC and South Korea all have developing and dynamic economies that will require increasing energy supplies for the foreseeable future. These countries are all exploring a variety of energy options while continuing to use existing fossil fuel systems. To avoid mass economic disruption, Australia's energy customers will gradually introduce many new energy technologies.

India is developing new nuclear technologies based on thorium (vice the current uranium and plutonium-based systems) but the domestic transportation industry is largely powered by fossil fuels. India is rapidly expanding the number of CNG powered vehicles in use; given Australia's position in the world CNG market, it is more likely that India will import additional fuel from Australia, not less.

The PRC is exploring a wide variety of energy solutions, including solar, hydroelectric and nuclear technologies (see Appendix E for a brief explanation of the Chinese energy economy). Senator Milne expressed concern that the PRC could disrupt the Australian economy if it discontinues coal imports.[3] China's contract stipulation for annual price negotiations would seem to support this concern. Even if the PRC developed its alternative energy industry to the point that it could discontinue fossil fuel imports, Australia has other existing customers, and could sell its coal and natural gas on the world energy market.

Because of Australia's geographic location, it is unlikely that any potential adversary could blockade petroleum imports. New Zealand lies to the southeast and has enjoyed close relations with Australia since both nations became self-governing over a century ago. Australia has no southern neighbors and only three northern ones: East

Timor, Papua New Guinea and Indonesia. East Timor and Papua New Guinea both have small military forces incapable of projecting power outside their borders, and are heavily dependent on Australian development and security assistance. Only Indonesia has sufficient military power to challenge the Australian Defense Forces. In spite of occasional diplomatic disagreements, Indonesia is unlikely to threaten Australia with an embargo due to the difficulty of interdicting Australia's sea lines of communication and the international condemnation such actions would provoke.

Abundant domestic supplies of natural gas also make it unlikely that a foreign nation could embargo petroleum supplies as a weapon. While domestic petroleum consumption makes Australia a net importer, the country could substitute its abundant natural gas for petroleum in many transportation applications. This assumes that fracking does not increase Australian petroleum production. If the Australians do adopt wide-scale fracking, domestic production could rise to meet consumption and eliminate the need for imported fuel.

Given Australia's proven energy reserves, its diverse customer base and economic self-sufficiency, it is unlikely that any single foreign energy customer could pressure the country to modify its historic and cultural ties with the United States. Military and economic cooperation between the countries remains strong and annual economic activity (both imports and exports) continue to expand. Australia enjoys Most Favored Nation trading status with the United States, and remains in negotiation with the United States and other countries to implement the Trans-Pacific Partnership.

In addition, the United States and Australia negotiated basing rights for the US military in Australia.[4] US Marines are currently deployed to Darwin in the Northern

Territories on a rotation basis; plans are to have about 2,500 based in Australia by 2016. The primary mission of this group will include assisting the Australian Defense Force as it integrates its new amphibious warfare vessels and tactics into the Australian order of battle.[5]

Recommendations for Future Study

Australia's dynamic energy field provides numerous areas for future study. Currently, no Australian government agency tracks off-grid power generation or the use of solar power for hot water heating. Continued research into wave, tidal and ocean current power generation will better inform the Australian government's efforts to promote these technologies. While tidal power stations have operated for decades, wave and ocean current power generation is a relatively new and unexplored field. Australia could position itself as a world leader in this zero-carbon, low-impact technologies and earn considerable foreign exchange selling these clean energy products worldwide.

Currently, the Australian government has a hands-off approach to the use of Aboriginal lands for wind and solar power generation. Exploratory studies would indicate the most efficacious locations for wind and solar farms in these areas; the Aboriginal communities could then make the choice whether to install wind or solar farms, as most appropriate to their individual circumstances.

The US military is currently experimenting with biofuels to reduce the environmental impact of security operations. The Australian military uses similar equipment (in the case of the C-130 and F/A-18, US produced), and could also reduce the environmental impact of its operations through the use of biofuels.

The global energy economy is evolving daily as the world economy and population continue to grow. Whatever political changes occur, nothing will change the geographic realities of the United States and Australia. Australia will remain an Anglophone island in southern Asia, dependent on maritime trade that must pass though sea lanes controlled by nations with interests that could be at odds with Australia. The United States needs a strong, stable Australia as a political partner for the promotion of liberal democratic principles.

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GLOSSARY

Alternative Energy. This is a broad category that includes any energy source that is not based on fossil fuels. Examples include: wind, solar, hydro-electric, nuclear, wave, geothermal.

Anthracite. The most desirable grade of coal, anthracite has the lowest moisture content and greatest energy per unit of weight of any form of coal. The moisture level and high energy potential makes anthracite more suitable for long-distance transport than black or brown coal. The carbon content of anthracite is over 90 percent.[1]

Barrels Per Day. A standard measure of production in the petroleum field. Each barrel of oil production is 42 US gallons of product.

Billion Cubic Feet. A standard measurement of production in the natural gas industry.

Biofuel. Biofuel is a broad term that covers any fuel that originates from a biological source that lived recently. This differentiates biofuel from fossil fuel, which was originally organic material but metamorphosed into hydrocarbon over millennia. The most familiar in the United States is ethanol (generally derived from corn) but methane derived from sewage is also considered biofuel.

Black Coal. Black coal is intermediate in quality between brown coal and anthracite. Black coal contains bitumen (a tarry hydrocarbon liquid), hence the synonym bituminous coal. The carbon content (and thus, energy potential) of black coal is between 60 and 80 percent.[2]

Blended Fuels. These are mixtures of gasoline and renewable liquids, most often alcohol. Both the United States and Australia use blended fuels to reduce their dependence on imported petroleum. Blended fuels range in alcohol content from five percent to 90 percent. In Brazil, pure alcohol fuel is readily available.

Brown Coal. Also called lignite, brown coal is considered a relatively low-grade fuel, and has a high moisture content compared to bituminous (or black) coal and a carbon content below 50 percent. This makes brown coal less desirable for long distance transport. Brown coal is used primarily for power generation, and produces the highest levels of tarry vapor when burned.[3]

Coal Seam Gas. Natural gas associated with coal deposits. CSG was traditionally considered a hazardous byproduct of coal mining. More recently, improvements in recovery technologies have made CGS an economically viable source of natural gas. CSG is more commonly called coal seam methane in the United States.

Cross-benching. When a member of a minority party agrees to caucus with the ruling coalition in order to create a quorum.

Fossil Fuel. Fossil fuels are hydrocarbons that originate from remains of organisms that change over geologic timeframes into useable fuels. Fossil fuels include liquids, solids and gases and are found under much of the Earth's surface in some form and concentration.

Fracking. The process of hydraulic fracturing of the bedrock to release natural gas or petroleum that would not otherwise be economically recoverable. Fracking involves forcing fluid (often water) into pilot wells drilled into the target bedrock. This fluid fractures the bedrock, allowing the recovery of the hydrocarbon. Fracking is controversial; residents in affected areas are often concerned that fracturing the bedrock may allow the hydrocarbons to contaminate ground water.

Known Reserves. These are the best estimates geologists give for the hydrocarbons present in a given area (usually referred to as a field in the fossil fuel industry). These estimates tend to be conservative, and are often further clarified as recoverable and non-recoverable reserves.

Millions of Short Tons. A unit of mineral production used primarily in the coal industry.

Molten Salt Reactor. In a conventional power reactor, the cooling fluid is water, often under high pressure. The use of high pressure coolant complicates reactor engineering. A MSR uses a liquid salt mixture as a coolant; unlike water cooled systems, the coolant in MSRs remains close to atmospheric pressure, which both reduces the need for high-pressure piping and reduces the chance of a radioactive release in the event of a breach of the cooling system. As an additional advantage, the coolant in MSRs operates at higher temperatures, allowing for greater thermal efficiencies in power production.

Natural Gas. Natural gas is a broad term to describe hydrocarbon gasses recovered from the ground or seabed. Natural gas can contain a variety of combustible gasses, including methane, ethane, propane and butanes; generally methane is the largest component of natural gas, followed by ethane. Natural gas can be found independent of other hydrocarbon fuels (unassociated fields) or in conjunction with liquid or solid fuels (associated fields). Long considered a hazardous waste product (especially in the petroleum industry), the global natural gas market is growing annually. Natural gas is typically processed near the wellhead to remove contaminates; once ready for market, the resulting product is pure hydrocarbon and burns very cleanly. This makes natural gas highly attractive a fuel with high energy content and low polluting residue.

Petajoules. A unit of industrial energy generation common outside the United States. One joule equals one watt of energy for one second.

U.S. Central Command. The military organization that controls all US military activity in the Middle East and Central Asia.

[1] EIA, “Coal Explained,” May 27, 2014, accessed July 3, 2013, http://www.eia.doe.gov/energyexplained/index.cfm?page=coal_home.

[2] Ibid.

[3] Ibid.

APPENDIX A

INTERVIEW QUESTIONS FOR POLITICIANS

1. Does Australia's fossil fuel strategy favor exports or internal consumption?
2. Do you see Australia greatly reducing internal consumption of fossil fuels? If so, will the decrease be due to lower energy demands, use of alternative/nuclear energy or a combination of both reduced demand and non-fossil fuel based technologies?
3. Australia currently exports considerable coal to the PRC; if Australia pursues "green power" initiatives, will the country continue to export fossil fuels?
    a. Exporting coal to the PRC just moves the carbon and pollution problems off-coast; will "green" elements in Australia demand an end to these exports?
4. Assuming Australia vigorously pursues alternative energy and conservation strategies, what steps will the government take to prevent economic repercussions/disruptions?
5. To what extent does the presence of oil and natural gas in the area affect Australia's relations with Indonesia and Timor l'East?
    a. Australia was directly involved in the Indonesian withdrawal from Timor; will Australian government or commercial entities pursue energy contracts with Timor?
6. Given the country's available natural gas reserves, will Australia move to use natural gas to fuel vehicles in the same manner that Pakistan has?
7. Given the availability of domestic uranium supplies, will Australian laws change to allow for nuclear power plants?
    a. If Australia decided to build a nuclear plant, would it process fuel domestically or purchase processed fuel?
    b. Would Australia build its own plant or purchase a "turn-key" facility?

APPENDIX B

INTERVIEW QUESTIONS FOR TECHNICAL EXPERTS

1. How will the Green movement affect Australia's domestic energy production?
2. What percentage of Australians uses "off-grid" power (e.g. power that is not generated at a large-scale plant)?
3. Does Australia use long distance high tension lines to supply communities in the interior of the continent?
4. Australia seems to be committing to low-emission power generation; will this affect Australia selling coal to the PRC?
5. Given the county's extensive coastline, is Australia pursuing wave technology for power generation?
6. Does Australia's fossil fuel strategy favor exports or internal consumption?
7. Do you see Australia greatly reducing internal consumption of fossil fuels? If so, will the decrease be due to lower energy demands, use of alternative/nuclear energy or a combination of both reduced demand and non-fossil fuel based technologies?
8. Australia currently exports considerable coal to the PRC; if Australia pursues "green power" initiatives, will the country continue to export fossil fuels?
    a. Exporting coal to the PRC just moves the carbon and pollution problems off-coast; will "green" elements in Australia demand an end to these exports?
9. Assuming Australia vigorously pursues alternative energy and conservation strategies, what steps will the government take to prevent economic repercussions/disruptions?
10. To what extent does the presence of oil and natural gas in the area affect Australia's relations with Indonesia and Timor l'East?
    a. Australia was directly involved in the Indonesian withdrawal from Timor; will Australian government or commercial entities pursue energy contracts with Timor?
11. Given the country's available natural gas reserves, will Australia move to use natural gas to fuel vehicles in the same manner that Pakistan has?
12. Given the country's proven uranium deposits, will Australian laws change to allow for nuclear power generation?
    a. If Australia decided to build a nuclear plant, would it process fuel domestically or purchase processed fuel?
    b. Would Australia build its own plant or purchase a "turn-key" facility?

APPENDIX C

THE NUCLEAR PLANT CONSTRUCTION CYCLE

Under ideal circumstances, it takes approximately five years to take a single nuclear power plant from conception to operational status; 10-15 years is more typical.[1] That estimate assumes that political consensus allows plant construction to progress without protests or legal action, that Japan has a site identified for the plant, and that the specialized engineering personnel and equipment is available. Simultaneously building enough nuclear power stations to allow Japan to discontinue fossil fuel imports would stress the world nuclear power industry to the extent that the time to build multiple nuclear power facilities simultaneously would be considerably longer.

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[1] Australian Department of Resources, Energy and Tourism, *Australian Resource Assessment*, 175.

APPENDIX D

ELECTRICAL VEHICLE STATISTICS

According to the Australian Bureau of Statistics, there were 15,384,634 private passenger, camper and light commercial vehicles in Australia in 2012.[1] A negligible number of these are non-petroleum powered (the Australian Bureau of Statistics groups these as "LPG/Dual Fuel/Other" but does not specifically identify electric vehicles); given the average age of the fleet in 2012 was 10 years, it is unlikely that many of these vehicles are electric powered.[2] For the purposes of this estimate, the author excluded heavy commercial and public transport vehicles, which may perform services (long distance transport, for example) which could make these poor candidates for conversion to electric power. Assuming that each vehicle has an engine of 100 horsepower on average, and that one percent of the existing light vehicles is already electric powered, the formula for converting the existing light vehicle capacity to electric power is:

100 X 15,230,787 X 746 = 1,136,216,759,436 or about 1,136 gigawatts

Note that these figures are somewhat optimistic, and assume the following:

1. No storage loss in the battery or fuel cell
2. That each vehicle will have a 100 horsepower motor
3. Perfect conversion of power from the central grid to the battery or fuel cell in the vehicle
4. That 1 percent of the existing pool of these vehicles are already electric powered and thus will not require replacement
5. That sufficient supplies of key materials for high-efficiency storage devices and motors are available at economically viable prices

Of course, these are merely engineering estimates and do not account for factors such as the cost of vehicle replacement or the implementation delays that building 1,136 gigawatts of power generation and distribution will cause.

According to the EIA, Australia could generate 59.134 gigawatts in 2010.[3] Australian power generation capacity has increased by about one percent per year over the past five years,[4] so building 1,136 gigawatts of generating and transmission capacity in the near future is possible but would be expensive, especially in remote areas.

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[1] Australian Bureau of Statistics, "Motor Vehicle Census, Australia, 31 Jan 2012," January 31, 2012, accessed July 2, 2013, http://www.abs.gov.au/ausstats/abs@.nsf/mf/9309.0home.

[2] Ibid.

[3] EIA, "International Energy Statistics," accessed June 20, 2013, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=7.

[4] Ibid

APPENDIX E

THE ENERGY POLICY OF THE PRC

The Information Office of the State Council of the PRC issued China's *Energy Policy 2012* (the country's most recent energy guidance) in October 2012.[1] Intended as both a public policy statement and a guiding framework for internal use, the Energy Policy is a thorough review of both internal energy production and consumption and China's position in the world energy market. *Energy Policy 2012* explicitly links energy availability with economic growth and social stability, particularly in Tibet, Inner Mongolia and Xingjian[2]—all areas with substantial non-ethnic Chinese populations prone to antipathy with the central government.[3]

According to the *Energy Policy*, in 2011, the PRC produced more energy than any country on Earth; the EIA reports that in October 2013, China became the largest petroleum importer in the world.[4] In spite of this, the Chinese government believes the country suffers from a per capita scarcity of domestic energy sources due to China's enormous population.[5] China claims to be 90 percent self-sufficient in energy, and actively seeks energy resources across the globe,[6] including some areas (such as Central Asia) that were formally under the control of the Soviet Union to secure the remainder.[7] The PRC appears to seek fossil fuel supplies from a variety of countries rather than rely on a small number of sources; figure 14 demonstrates the diversity of China's petroleum sources.

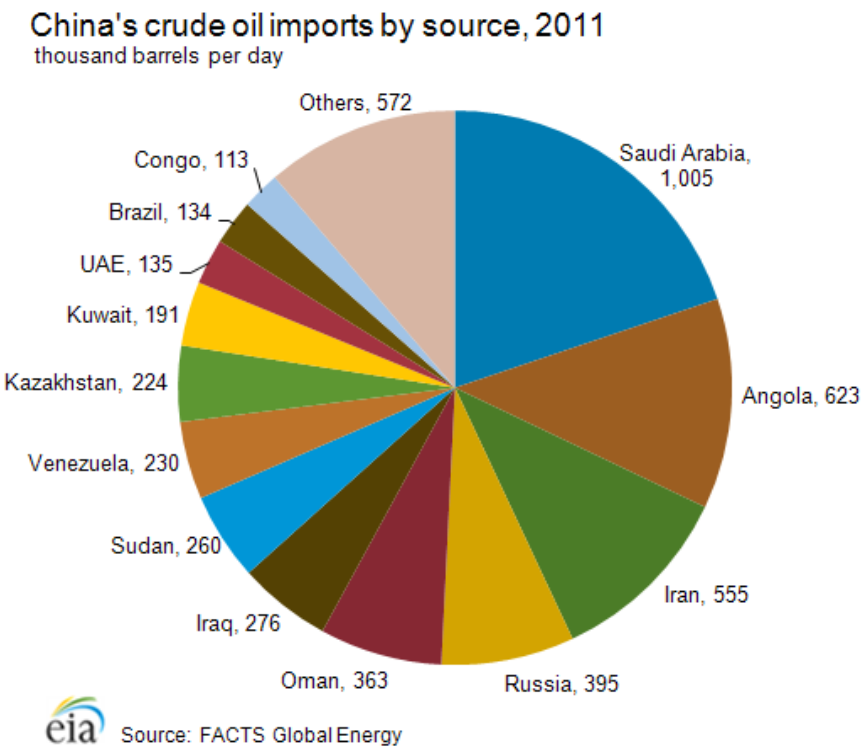

Figure 14. China's Crude Oil Imports by Source, 2011

Source: US Energy Information Administration, *China Country Analysis Brief*, accessed December 19, 2013, http://www.eia.gov/countries/analysisbriefs/China/images/crude_oil_imports_source.png, 12.

The PRC recognizes that since the 1949 revolution, the national energy infrastructure has developed inefficiently, leading to waste and unnecessary levels of pollution.[8] In 2013, the air quality in Beijing degraded to the point that it was a health hazard to all humans, not only those with respiratory conditions.[9] According to National Aeronautics and Space Administration, the dangerous particulate pollution resulted from fossil fuel use and agricultural burning—both causes under human control. Currently, China relies on coal to produce about 80 percent of its power.[10] In recent years, the PRC has eliminated numerous small, less efficient coal fired power plants, and taken major

strides to reduce sulfur emissions from the coal plants that remain in service.[11] Natural gas use has increased in recent years but only accounted for four percent of energy production in 2009.[12] Replacing coal with natural gas to produce power will help China achieve its pollution reduction goals. In September 2013, the PRC committed to reducing carbon emissions to 55 to 60 percent of 2005 levels by 2020.[13]

China's government understands that the country's rapidly expanding economy requires reliable energy, and that many of the coal-fired plants currently in operation produce unacceptable levels of pollution. As figure 15 shows, coal supplies 70 percent of energy consumed in the PRC. The PRC pursues an energy strategy that aggressively develops all potential sources, including coal and natural gas, nuclear, and renewable (wind, solar and hydroelectric) power accordingly. Given the need to maintain economic growth for its growing population and the dependence on fossil fuels to provide the energy that growth requires, it is unlikely that the PRC would use its position as a customer of Australian fossil fuels to influence Australia's government policies. On the contrary: according to the National Bureau of Asian Research, China deliberately diversifies foreign fossil fuel suppliers to avoid dependence on any single nation due to fears that foreign powers could use such dependence as a political tool.[14]

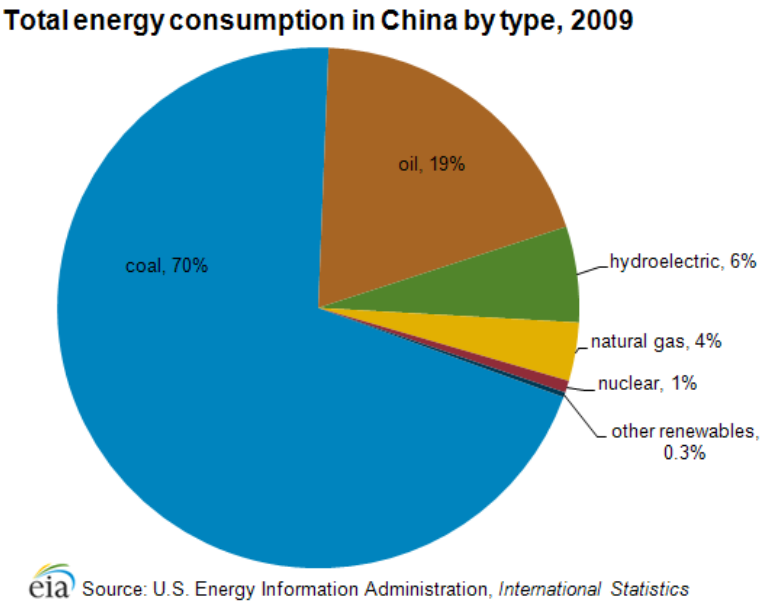

Figure 15. Total Energy Consumption in China by Type, 2009.

Source: US Energy Information Administration, "China Country Analysis Brief," accessed December 19, 2013, http://www.eia.gov/countries/analysisbriefs/China/images/energy_consumption_by_type.png, 3.

Chinese energy policy focuses to maintain supplies to ensure continued economic growth, as evidenced by the government's emphasis on diversifying internal and external energy sources. This strongly indicates that the PRC will continue to rely on a variety of external fossil fuel suppliers until improvements in domestic sources and efficiencies make the country energy independent.

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[1] Information Office of the State Council of the People's Republic of China, *China's Energy Policy 2012*, October 24, 2012, accessed November 25, 2013, http://www.china.org.cn/government/whitepaper/node_7170375.htm.

[2] Ibid.

[3] Edward Wong, "China police fire on Tibetan protesters report says" *New York Times*, October 9 2013; Chen Aizhu "China says Xinjiang police station attacked by axe,

knife-wielding mob, 11 dead," Reuters, November 17 2013, accessed November 29, 2013, http://www.reuters.com/article/2013/11/17/us-china-xinjiang-violence-idUSBRE9AG02G20131117; Mihray Abdilim, "Inner Mongolians Escalate Land Protest," *Radio Free Asia*, April 4 2012.

[4] EIA, "China Energy Brief."

[5] Information Office of the State Council of the People's Republic of China, *China's Energy Policy 2012.*

[6] John Daly, "China's Energy Policies Unsettle Neighbors Both East and West," Oilprice.com, July 28 2013, accessed November 29, 2013, http://oilprice.com/Geopolitics/Asia/Chinas-Energy-Policies-Unsettle-Neighbors-Both-East-and-West.html.

[7] Information Office of the State Council of the People's Republic of China, *China's Energy Policy 2012*; Daly.

[8] Information Office of the State Council of the People's Republic of China, *China's Energy Policy 2012*.

[9] National Aeronautics and Space Administration, "Air Quality Suffering in China," July 28, 2013, accessed November 25, 2013, http://www.nasa.gov/multimedia/imagegallery/image_feature_2425.html.

[10] EIA, "China Energy Brief."

[11] Information Office of the State Council of the People's Republic of China, *China's Energy Policy 2012*.

[12] EIA, "China Energy Brief."

[13] Suwatchai Songwanich, "China's changing energy policy," The Nation, September 9 2013, accessed November 25, 2013, http://www.nationmultimedia.com/opinion/Chinas-changing-energy-policy-30214415.html.

[14] Michael Bradshaw, Mikkal E. Herberg, Amy Myers Jaffe, Damien Ma, and Nikos Tsafos, *Asia's Uncertain LNG Future* (Seattle: National Bureau of Asian Research, 2013).

APPENDIX F

THE CARBON TAX

In September 2011, the Australian parliament introduced a group of 18 interrelated laws to tax and regulate carbon dioxide emissions generated by burning fossil fuels; the Clean Energy Act of 2011 (informally referred to as the carbon tax) is the central enabling legislation.[1] The act created a fixed number of emission units, which organizations that burn fossil fuels could eventually trade in a carbon market. Supplementary legislation created the Clean Energy Regulator, a new government agency "which will administer and enforce the carbon price mechanism, the National Greenhouse and Energy Reporting System, the Renewable Energy Target and the Carbon Farming Initiative."[2]

The Australian Senate passed the legislation on November 8, 2011, which was the final legislative step to implementation.[3] According to Article 58 of the Australian constitution, the Governor-General (the British Crown's personal representative in Australia) could "withhold the Queen's assent" (in effect, veto) the bill.[4] Article 59 of the Australian constitution allows the British Sovereign to repeal any act up to one year after it has passed into law.[5] In practice, neither the Governor-General nor Queen Elizabeth has ever interfered with the passage of an Australian act into law, and the deadline to do so in this case has passed.

The Clean Energy Act of 2011 required organizations that burn fossil fuel pay a tax per ton of carbon dioxide emission; the Clean Energy Regulator evaluates each type of fuel (brown coal, black coal, natural gas, etc.) and formulates a standard tariff rate for

each fuel type.[6] The carbon tax legislation took effect on July 1, 2012. According to the *Wall Street Journal:*

> The tax will be charged at a fixed price of 23 Australian dollars (US$23.50) per carbon ton from the country's top 500 polluters starting from July 2012, increasing 2.5 percent annually until 2015 before changing to a floating-rate price with the government controlling the amount of tradable permits released annually and implementing a price floor and ceiling. At that point companies will be able to trade carbon credits and the scheme is expected to be linked with other systems in New Zealand and Europe.[7]

Australia projected that the tax will reduce annual carbon emissions by 160 million tons by 2025.[8]

The implementation and long-term effects of the carbon tax were matters of considerable debate in Australia. Of significant concern was the effect the carbon tax would have on Australian businesses. Currently, Australia produces about 75 percent of its electricity nationwide using coal-fired plants. Many of these plants burn brown coal, which has a lower net energy and greater tendency to self-ignition[9] than black coal or anthracite and is therefore less desirable to export customers. The carbon tax raised the price of electricity, and thus expenses for all businesses that purchase electricity. In addition to the increased costs for all businesses and private electricity users, some processes (such as ore refining) are energy intensive and currently rely on coal. The carbon tax could have forced these processes overseas, resulting in a net loss of jobs to the economy.[10] The Australian Competition and Consumer Commission threatened to levy fines exceeding a million dollars on any business that justified future price increases on the tax, or even offered "pre-tax" sales.[11]

Prime Minister Tony Abbott made the repeal of the carbon tax law an early priority for his administration.[12] The House of Representatives voted to repeal the tax

soon after the September 2013 federal election; the Senate made this legislation a major priority when the body reconvened in July 2014.[13] After considerable debate and dissention from the Green and Labor parties, the Senate voted to repeal the law on July 17, 2014.[14]In place of the Carbon Tax, the Abbott administration implemented the DAP to reduce carbon dioxide emissions, which relies on government funded incentives to reduce carbon emissions vice a punitive tax.[15]

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[1] Clean Energy Act 2011 (Australia).

[2] Clean Energy Regulator Act, 2011 (Australia).

[3] Andrew Critchlow, "Australia's Carbon Tax Clears Final Hurdle," *Wall Street Journal*, 8 November 2011.

[4] The Australian Constitution, article 58.

[5] Ibid.

[6] Clean Energy Regulator, "About the carbon pricing mechanism," accessed November 12, 2013, http://www.cleanenergyregulator.gov.au/Carbon-Pricing-Mechanism/About-the-Mechanism/Pages/default.aspx.

[7] Critchlow.

[8] Ibid.

[9] EIA, "Coal Explained."

[10] Abetz interview.

[11] Miranda Devine,"The truth will out on Labor's carbon scam," *Daily Telegraph*, 17 November 2011.

[12] Anderson and Koh.

[13] Department of the Environment, "Repealing the Carbon Tax," accessed January 19, 2014, http://www.environment.gov.au/topics/cleaner-environment/clean-air/repealing-carbon-tax.

[14] Amy Bainbridge, "Carbon tax repeal: Electricity bills set to fall after Senate passes repeal bills," Australian Broadcast Corporation, July 17, 2014, accessed July 20,

2014, http://www.abc.net.au/news/2014-07-17/what-the-carbon-tax-repeal-means-for-consumers/5604458.

[15] Australian Department of the Environment, *Emissions Reduction Fund Green Paper* (Canberra: Commonwealth of Australia, 2013), 2.

APPENDIX G

OPEC AND AUSTRALIA

The OPEC currently consists of 12 member states: Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela. According to the OPEC Statute (the organization's bylaws) OPEC's purpose is:

> the coordination and unification of the petroleum policies of the Member Countries and the determination of the best means for safeguarding their interests, individually and collectively . . . Due regard shall be given at all times to the interests of the producing nations and the necessity of securing a steady income of the producing countries; an efficient, economic and regular supply of petroleum to consuming nations; and a fair return on their capital to those investing in the petroleum industry.[1]

In addition to formulating policy for the organization, the cartel sets market prices and maximum production limits for each member state. OPEC countries routinely ignore these restrictions, producing and pricing oil according to each nation's perceived best interest.[2]

In spite of the cartel's use of oil as a political weapon in 1973, several factors would mitigate against OPEC employing such a tactic against Australia today. The first is that Australia is unlikely to have a political disagreement with a cartel member of such intensity that the organization would react with an embargo. Australia has some on-going disputes with neighboring Indonesia, but diminished production forced Indonesia to leave OPEC in January 2009.[3] A second impediment is the fact that many major oil exporters (including Russia, Mexico and Norway) are not OPEC members.[4] Finally, of all Australia's oil suppliers, only the United Arab Emirates and Nigeria are OPEC members

(supplying roughly 10 and five percent of 2013 imports respectively).[5] These factors make it unlikely that OPEC could restrict Australian oil imports as a political weapon.

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[1] Organization of the Petroleum Exporting Countries Secretariat, *OPEC Statute* (Vienna, Austria: OPEC, 2012), accessed July 5, 2014, http://www.opec.org/opec_web/static_files_project/media/downloads/publications/OPEC_Statute.pdf, 1.

[2] Toyin Falola and Ann Genova, *The Politics of the Global Oil Industry: An Introduction* (Westport, CT: Praeger, 2005), 67.

[3] John Aglionby, "Indonesia Pulls Out of OPEC," *Financial Times*, May 28, 2008, accessed June 25, 2014, http://www.ft.com/intl/cms/s/0/d0e346fe-2c87-11dd-88c6-000077b07658.html#axzz38ioqnoX4.

[4] Falola and Genova, 67.

[5] UN Trade Statistics, "Australia 2013, Import of Petroleum Oils by Partner," Twitter, June 17, 2014, accessed July 1, 2014, https://twitter.com/UNTradeStats/status/478968813590175744.

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